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GENE HAWKINS, JR.

U.S. Department
of Transportation
**Federal Highway
Administration**

Part VI
Standards and Guides for Traffic Controls for Street and Highway Construction, Maintenance, Utility, and Incident Management Operations.

Part VI of the Manual on Uniform Traffic Control Devices (MUTCD)

1988 Edition of MUTCD, Revision 3
September 3, 1993

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PART VI
TRAFFIC CONTROLS FOR STREET AND HIGHWAY CONSTRUCTION, MAINTENANCE, UTILITY, AND INCIDENT MANAGEMENT OPERATIONS

6A. INTRODUCTION

During any time the normal function of a roadway is suspended, temporary traffic control planning must provide for continuity of function (movement of traffic, pedestrians, transit operations, and access to property/utilities). The location where the normal function of the roadway is suspended is defined as the work space. The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and material. Sometimes there may be several work spaces within the project limits. This can be confusing to drivers because the work spaces may be separated by several miles. Each work space should be adequately signed to inform drivers of what to expect.

Effective temporary traffic control enhances traffic safety and efficiency, regardless of whether street construction, maintenance, utility work, or roadway incidents are taking place in the work space. Effective temporary traffic control must provide for the safety of workers, road users, and pedestrians. At the same time, it must provide for the efficient completion of whatever activity suspended normal use of the roadway.

No one set of signs or other traffic control devices can typically satisfy all conditions for a given project. At the same time, defining detailed standards that would be adequate to cover all applications is simply not practical. Part VI displays several diagrams that depict common applications of standard temporary traffic control devices. The traffic control selected for each situation should be based on type of highway, traffic conditions, duration of operation, physical constraints, and the nearness of the work space to traffic.

Traffic control plans and devices may be adopted by the authority of a public body or official having jurisdiction for guiding traffic. The plans and devices should follow the principles set forth in this Part but may deviate from the typical drawings to allow for conditions and requirements of a particular site or jurisdiction.

The criteria of this part are intended to apply to both rural and urban areas. Rural highways are normally characterized by lower volumes, higher speeds, fewer turning conflicts, and fewer conflicts with pedestrians. Urban street traffic is typically characterized by relatively low speeds, wide ranges in traffic volume, narrower roadway lanes,

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frequent intersections, significant pedestrian traffic, and more roadside obstacles.

It is essential that concern for traffic safety, worker safety and efficiency of traffic movement form an integral element of every temporary traffic control zone, from planning through completion of work activity. Simultaneously, the control selected must permit efficient maintenance/ construction of roadways and roadway appurtenances.

6B. FUNDAMENTAL PRINCIPLES

All traffic control devices used on street and highway construction, maintenance, utility, or incident management (temporary traffic control) operations shall conform to the applicable specifications of this manual.

Special plan preparation and coordination with transit and other highway agencies, police and other emergency units, utilities, schools, railroads, etc. may be needed to reduce unexpected and unusual traffic operation situations.

During temporary traffic control activities, commercial vehicles may need to follow a different route from automobiles because of bridge, weight, clearance, or geometric restrictions. Also, vehicles carrying hazardous materials may need to follow a different route from other vehicles. Truck Route National Network and hazardous cargo signs are included in section 2B-43.

Principles and procedures, which experience has shown tend to enhance the safety of motorists and workers in the vicinity of temporary traffic control areas, are included in the following listing. These principles and procedures provide a guiding philosophy of good temporary traffic control used in zone traffic control for the practitioner. They do not establish specific standards and warrants (individually addressed in the succeeding sections of this part).

1. Traffic safety in temporary traffic control areas should be an integral and high-priority element of every project from planning through design and construction. Similarly, maintenance and utility work should be planned and conducted with the safety of motorists, pedestrians, and workers kept in mind at all times. Formulating specific plans for incident management traffic control is difficult because of the variety of situations that can arise. Nevertheless, plans should be developed in sufficient detail to provide safety for motorists, pedestrians, workers, and enforcement/emergency personnel and equipment.

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a. The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of temporary traffic control zones. The goal should be to route traffic through such areas using geometrics and traffic control devices comparable to those for normal highway situations.

b. A traffic control plan, in detail appropriate to the complexity of the work project or incident, should be prepared and understood by all responsible parties before the site is occupied. Any changes in the traffic control plan should be approved by an official trained in safe traffic control practices.

2. Traffic movement should be inhibited as little as practicable.

a. Traffic control in work and incident sites should be designed on the assumption that drivers will reduce their speeds only if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practical.

b. Frequent and abrupt changes in geometrics—such as lane narrowing, dropped lanes, or main roadway transitions requiring rapid maneuvers—should be avoided.

c. Provisions should be made for the safe operation of work or incident management vehicles, particularly on high-speed, high-volume roadways.

d. Roadway occupancy and work completion time should be minimized to reduce exposure to potential hazards.

e. Pedestrians should be provided with access and safe passage through the temporary traffic control zone at all times.

f. Roadway occupancy should be scheduled during off-peak hours and, if necessary, night work should be considered.

3. Drivers and pedestrians should be guided in a clear and positive manner while approaching and traversing the temporary traffic control zone.

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a. Adequate warning, delineation, and channelization by means of proper pavement marking, signs, or use of other devices that are effective under varying conditions of light and weather should be provided where appropriate to assure the driver and pedestrian of positive guidance before approaching and while passing through the work area.

b. Signs, pavement markings, channelizing devices, delineators, and other traffic control devices that are inconsistent with intended travel paths through long-term work spaces should be removed. In short-duration and mobile work spaces where retained permanent devices are inconsistent with intended travel paths, attention should be given to devices that highlight or emphasize the appropriate path.

c. Flagging procedures, when used, can provide positive guidance to drivers traversing the temporary traffic control area. Flagging should be employed only when all other methods of traffic control are inadequate to warn and direct drivers.

4. To ensure acceptable levels of operation, routine inspection of traffic control elements should be performed.

a. Individuals who are trained in the principles of safe traffic control should be assigned responsibility for safety at work sites. The most important duty of these individuals is to ensure that all traffic control measures implemented on the project are necessary, conform to the traffic control plan, and are effective in providing safe conditions for motorists, pedestrians, and workers.

b. Modification of traffic controls or working conditions may be required to expedite safe traffic movement and to promote worker safety. It is essential that the individual responsible for safety have the authority to control the progress of work on the project with respect to obtaining safe conditions, including the authority to modify conditions or halt work until applicable or remedial safety measures are taken.

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c. Temporary traffic control areas should be carefully monitored under varying conditions of traffic volume, light, and weather to ensure that traffic control measures are operating effectively and that all devices used are clearly visible, clean, and in good repair.

d. When warranted, an engineering analysis should be made (in cooperation with law enforcement officials) of all accidents occurring in temporary traffic control zones. Temporary traffic control zones and accident records should be monitored to identify and analyze traffic accidents or conflicts. For example, skid marks or damaged traffic control devices may indicate the need for changes in the traffic control.

e. All traffic control devices should be removed when no longer needed. When work is suspended for short periods, advance warning signs that are no longer appropriate shall be removed, covered, or turned, and other inappropriate devices removed from the work area so they are not visible to drivers.

5. The maintenance of roadside safety requires attention during the life of the temporary traffic control zone because of the potential increase in hazards.

   a. To accommodate run-off-the-road incidents, disabled vehicles, or emergency situations, it is desirable to provide an unencumbered roadside recovery area.

   b. Channelization of traffic should be accomplished by pavement markings, signs, and/or lightweight channelizing devices that will yield when hit by errant vehicles.

   c. Whenever practical, equipment, workers' private vehicles, materials, and debris should be stored in such a manner as not to be vulnerable to run-off-the-road vehicle impact.

   d. Pedestrian paths through the temporary traffic control zone should be protected to minimize pedestrian exposure to errant vehicles.

6. Each person whose actions affect temporary traffic control zone safety—from upper-level management

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personnel through field personnel—should receive training appropriate to the job decisions each is required to make. Only those who are trained in safe traffic control practices, and who have a basic understanding of the principles established by applicable standards and regulations (including those of the MUTCD), should supervise the selection, placement, and maintenance of traffic control devices in work and incident management areas.

7. The control of traffic through work areas is an essential part of street and roadway construction, utility and maintenance operations. For these operations there must be adequate legislative authority for the implementation and enforcement of needed traffic regulations, parking controls, speed zoning, and incident management. Such statutes must provide sufficient flexibility in the application of traffic control to meet the needs of changing conditions in work areas.

8. Maintaining good public relations is necessary. The cooperation of the various news media in publicizing the existence of and reasons for work sites can be of great assistance in keeping the motoring public well informed.

6C. TEMPORARY TRAFFIC CONTROL ELEMENTS

6C-1. TRAFFIC CONTROL PLANS

Traffic Control Plans (TCP's) play a vital role in providing continuity of safe and efficient traffic flow, to the extent interruptions in normal flow are necessary for temporary traffic control operations or other events that must temporarily disrupt normal traffic flow. Important auxiliary provisions that cannot conveniently be specified on project plans can easily be incorporated into Special Provisions within the TCP.

A TCP describes traffic controls to be used for facilitating vehicle and pedestrian traffic through a temporary traffic control zone. The plan may range in scope from being very detailed, to merely referencing typical drawings contained in the MUTCD, standard approved highway agency drawings and manuals, or specific drawings contained in contract documents. The degree of detail in the TCP depends entirely on the complexity of the situation, and TCP's should be prepared by persons knowledgeable about the fundamental principles of temporary

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traffic control and the work activities to be performed.

Traffic control planning requires forethought. Provisions may be incorporated into the project bid documents that enable contractors to develop alternate traffic control plans, which may be used only if the responsible agency finds they are as good as those provided in the plans/specifications. For maintenance and minor utility projects that do not require bidding, forethought must be given to selecting the best traffic control before occupying the temporary traffic control zone. Also, coordination must be made between projects to ensure that duplicate signing is not used and to ensure compatibility of traffic control between adjacent projects.

Modifications of TCP's may be necessary because of changed conditions or determination of even better ways of handling traffic safely and efficiently, while permitting efficient temporary traffic control activities to progress.

6C-2. DEFINITION OF TEMPORARY TRAFFIC CONTROL ZONE COMPONENTS

The temporary traffic control zone includes the entire section of roadway between the first advance warning sign through the last traffic control device, where traffic returns to its normal path and conditions. Most temporary traffic control zones can be divided into four areas: the advance warning area, the transition area, the activity area, and the termination area. Figure VI-1 illustrates these four areas.

The four components that constitute a temporary traffic control zone are described in the order that drivers encounter them. They include the following:

a. Advance Warning Area

In the advance warning area, drivers are informed of what to expect. The advance warning may vary from a single sign or flashing lights on a vehicle to a series of signs in advance of the temporary traffic control zone transition area. On freeways and expressways, where driver speed is generally in the higher range (45 mph or more), signs may be placed

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from 500 feet to 1/2 mile or more before the temporary traffic control zone. The true test of adequacy of sign spacing is to evaluate how much time the driver has to perceive and react to the condition ahead. In this regard, the use of speed, roadway condition, and related driver expectancy must be considered in order to derive a practical sign spacing distance. As a guide, table II-1 in section 2C-3 should be used in conjunction with consideration of actual or anticipated field conditions. Effective placement of warning signs for urban and rural locals is as follows:

(1) Urban

Warning sign spacings in advance of the transition area normally range from four to eight times the speed (mph) in feet, with the high end of the range being used when speeds are relatively high. When single advance warning signs are used (as in the case of low-speed residential streets), the advance warning area can be as short as 200 feet. When two or more advance signs are used on higher-speed streets such as major arterials, the advance warning area should extend a greater distance. (See table VI-3.)

(2) Rural

Rural roadways are characterized by higher speeds. Spacing for the placement of warning signs is substantially longer—from 8 to 12 times the speed (mph) in feet. Two or more advance warning signs are normally used in these conditions, the advance warning area should extend 1,500 feet or more in open highway conditions. (See table VI-3.)

Advance warning is normally not needed when the activity area is sufficiently removed from the driver's path that it does not interfere with traffic.

b. Transition Area

When redirection of the driver's normal path is required, traffic must be channelized from the normal path to a new path. This redirection is

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intended to occur at the beginning of the transition area. In mobile operations, this transition area moves with the work space. Transition areas usually involve strategic use of tapers, which (because of their importance) are discussed in more detail in section 6C-3.

c. Activity Area

The activity area is an area of roadway where the work takes place. It is composed of the work space and the traffic space, and may contain one or more buffer spaces.

(1) Work Space

The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and material. Work space may be fixed or may move as work progresses. Long-term work spaces are usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians.

(2) Traffic Space

The traffic space is the portion of the roadway in which traffic is routed through the activity area.

(3) Buffer Space

The buffer space is an optional feature in the activity area that separates traffic flow from the work activity or a potentially hazardous area and provides recovery space for an errant vehicle. Neither work activity nor storage of equipment, vehicles, or material should occur in this space. Buffer spaces may be positioned longitudinally and laterally, with respect to the direction of traffic flow.

(a) Longitudinal Buffer Space

The longitudinal buffer space may be placed in the initial portion of a closed lane in advance of the work space, as shown in figure VI-1. When a protection vehicle is placed in

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advance of the work space, only the space upstream of the vehicle constitutes the buffer space.

The longitudinal buffer space, as depicted in figure VI-2, should be used where a closed lane separates opposing traffic flows. Typically, it is formed as a traffic island and defined by channelizing devices.

A guide for the length of longitudinal buffer space is shown in table VI-1. The length may be adjusted to satisfy individual agency needs.

(b) Lateral Buffer Space

A lateral buffer space may be used to separate the traffic space from the work space, as shown in figure VI-1, or a potentially hazardous area, such as an excavation or pavement drop-off. A lateral buffer space also may be used between two travel lanes, especially those carrying opposing flows. The width of the lateral buffer space should be determined by engineering judgment.

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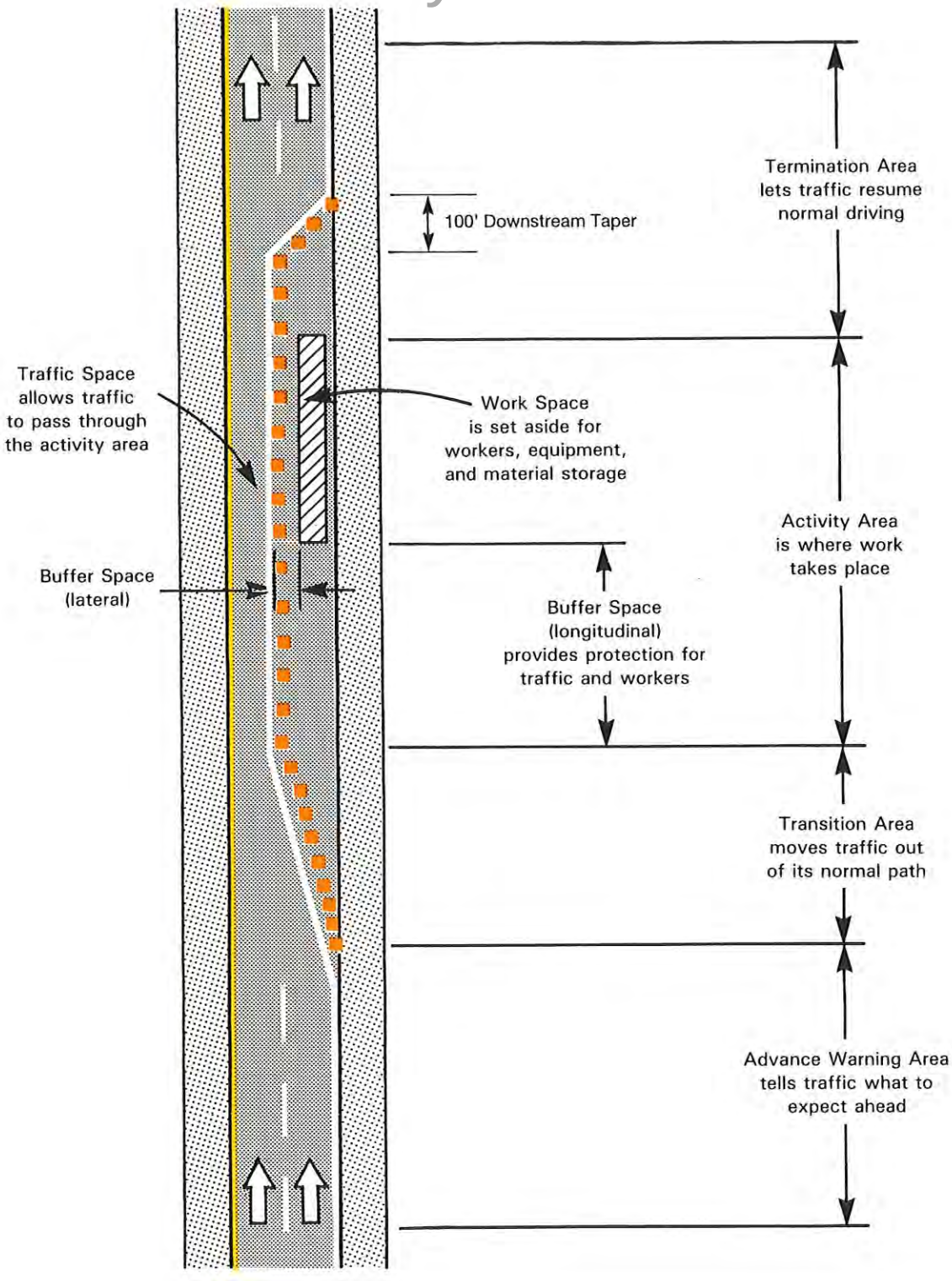

Figure VI-1. Component parts of a temporary traffic control zone.

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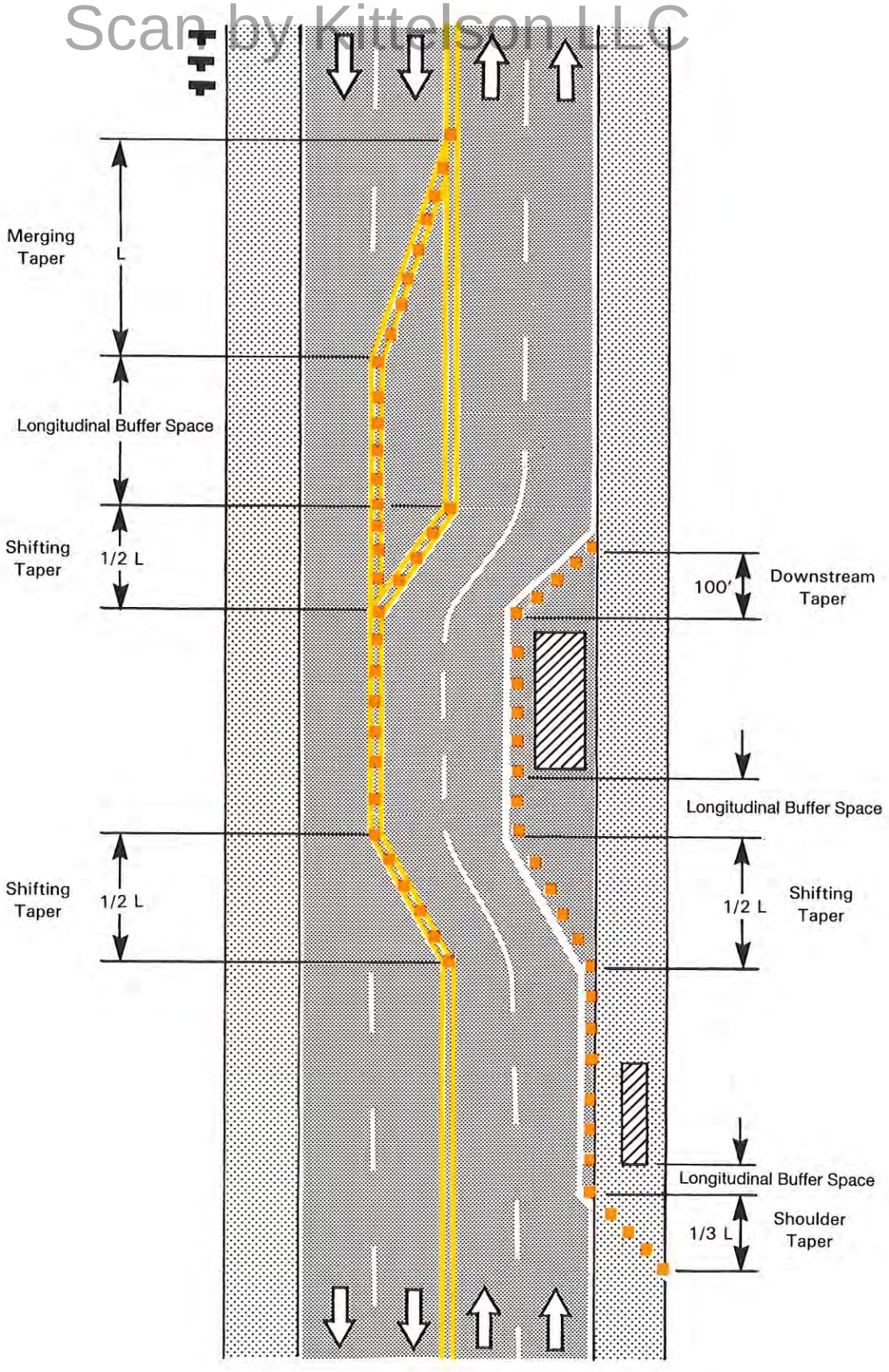

Figure VI-2. Tapers and buffer space.

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Table VI-1. Guidelines for length of longitudinal buffer space[1]

Speed* (mph)	Length (feet)
20	35
25	55
30	85
35	120
40	170
45	220
50	280
55	335
60	415
65	485

* Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed in mph.

[1]Based upon American Association of State Highway and Transportation Officials (AASHTO) braking distance portion of stopping sight distance for wet and level pavements (A Policy on Geometric Design of Highways and Streets, AASHTO, 1990, p. 120). This AASHTO document also recommends adjustments for the effect of grade on stopping and variation for trucks.

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(4) Incident Management Vehicle Storage Space

When work occurs on a high-volume, highly congested facility in an urban area, it is optional to allow space to store emergency vehicles (e.g., tow trucks) to respond quickly to traffic incidents. The storage space is typically provided at the beginning or end of the activity area, or both. An emergency vehicle storage area should not extend into any portion of the buffer space.

d. Termination Area

The termination area is used to return traffic to the normal traffic path. The termination area extends from the downstream end of the work area to the END ROAD WORK signs, if posted. Conditions may be such that posting of END ROAD WORK signs is not helpful. For example, the END ROAD WORK signs should normally not be used if other temporary traffic control zones begin within a mile of the end of the work space in rural areas, or about a quarter-mile within urban areas. For normal daytime maintenance operations, the END ROAD WORK SIGN is optional.

6C-3. TAPERS

A common important element of a temporary traffic control zone is a roadway taper. Tapers may be used in both the transition and termination areas. Tapers are created using a series of channelizing devices or pavement markings placed to move traffic out of or into its normal path. Whenever tapers are to be used near interchange ramps, crossroads, curves, or other influencing factors, it may be desirable to adjust the length of tapers. Longer tapers are not necessarily better than shorter tapers (particularly in urban areas characterized by short block lengths, driveways, etc.), because extended tapers tend to encourage sluggish operation and to encourage drivers to delay lane changes unnecessarily. The real test of taper length involves observation of driver performance after traffic control plans are put into effect. Types of taper lengths are presented in table VI-2. The maximum space between devices in a taper normally approximates the distance in feet of the speed

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Table VI-2. Taper length criteria for temporary traffic control zones

Type of taper	Taper length
Upstream tapers	
Merging taper	L minimum
Shifting taper	1/2 L minimum
Shoulder taper	1/3 L minimum
Two-way traffic taper	100 feet maximum
Downstream tapers (use is optional)	100 feet minimum

Formulas for L*

Speed	Formula
40 mph or less	$L = \frac{WS^2}{60}$
45 mph or greater	$L = W \times S$

*L = Taper length in feet.
W = Width of offset in feet.
S = Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed in mph.

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in miles per hour (i.e.: a 55 mph speed road should normally have devices spaced about 55 feet apart). Types of tapers are shown in figure VI-2 and the two-way traffic taper is shown in figure VI-3:

a. Merging Taper

A merging taper requires the longest distances because drivers are required to merge with an adjacent lane of traffic at the prevailing speed. The taper should be long enough to enable merging drivers to adjust their speeds and merge into a single lane before the end of the transition. For freeways, expressways, and other roadways having a speed of 45 mph or greater, the minimum length for merging tapers should be computed by a formula L = W x S. For residential, urban, and other streets with speeds less than 45 mph, the formula L = $(W \times S^2)/60$ should be used. Under either formula, L is the taper length in feet, W is the lateral shift of traffic due to the partially or fully closed lane (in feet), and S is the posted speed, the off-peak 85th percentile speed prior to work starting or the anticipated operating speed. The formula L = $(W \times S^2)/60$ is used for speeds less than 45 mph because slower traffic can merge safely in a shorter distance.

b. Shifting Taper

A shifting taper is used when merging is not required, but a lateral shift is needed. Approximately one-half L has been found to be adequate. Where more space is available, it may be beneficial to use longer distances. Guidance for changes in alignment may also be accomplished by using horizontal curves designed for normal highway speeds.

c. Shoulder Taper

A shoulder taper may be beneficial on high-speed roadways with improved shoulders that may be mistaken for driving lanes (when work is occurring in the shoulder area). If used, shoulder tapers approaching the activity area should have a length of about one-third L. If a shoulder is used as a travel lane either through practice or during a temporary traffic activity, a normal merging or shifting taper

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should be used. An example of a shoulder taper is presented in figure VI-2.

d. Downstream Taper

The downstream taper may be useful in termination areas to provide a visual cue to the driver that access is available to the original lane/path that was closed. When a downstream taper is used, it should have a minimum length of about 100 feet per lane, with devices spaced about 20 feet apart. An example of a downstream taper is shown in figure VI-2.

e. One-Lane, Two-Way Taper

The one-lane, two-way traffic taper is used in advance of an activity area that occupies part of a two-way roadway in such a way that a portion of the road is used alternately by traffic in each direction. Typically, traffic is controlled by a temporary traffic signal or a flagger. A short taper having a maximum length of 100 feet with channelizing devices at approximately 20-foot spacings should be used to guide traffic into the one-way section. An example of a one-lane, two-way traffic taper is presented in figure VI-3.

6C-4. DETOURS AND DIVERSIONS

At detours, traffic is directed onto another roadway to bypass the temporary traffic control zone. Detours should be signed clearly over their entire length so that motorists can easily determine how to return to the original roadway.

At diversions, traffic is directed onto a temporary roadway or alignment placed in or next to the right-of-way, e.g., median crossovers or lane shifts.

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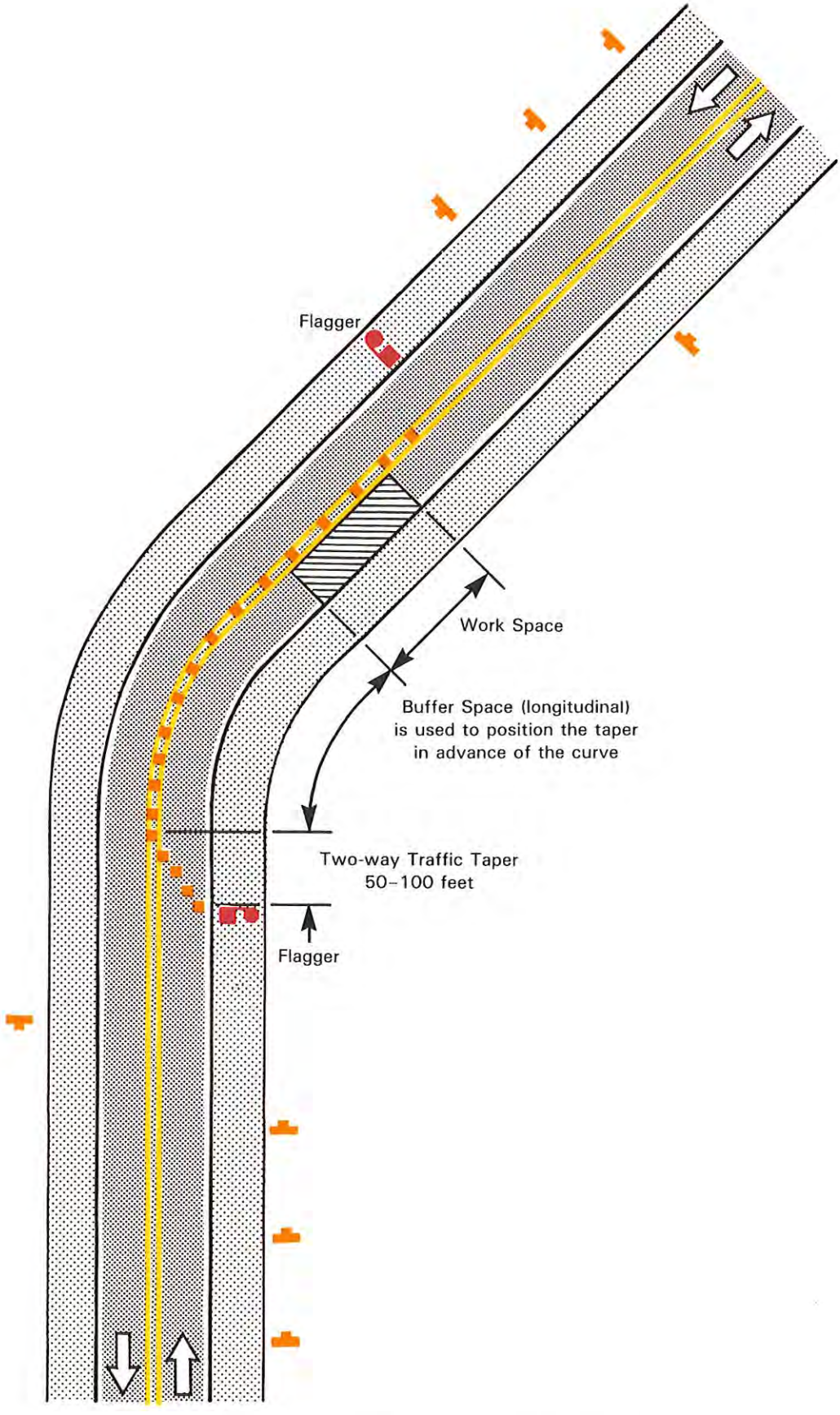

Figure VI-3. Example of one lane-two way traffic control.

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6C-5. ONE-LANE, TWO-WAY TRAFFIC CONTROL

Where traffic in both directions must, for a limited distance, use a single lane, provision should be made for alternate one-way movement through the constricted section. Some means of coordinating movements at each end shall be used to avoid head-on conflicts and to minimize delays. Control points at each end should be chosen to permit easy passing of opposing lines of vehicles. At a "spot" obstruction, however, such as an isolated pavement patch on roadways with lower speeds and adequate sight distance, the movement may be self-regulating.

Alternate one-way traffic control may be accomplished as appropriate by flagger control, a flag-carrying or official car, a pilot car, traffic signals, or by using stop or yield control. This section discusses each of these traffic control techniques. (See section 6E-2 for flagger qualifications.)

a. Flagger Method

Where a one-lane two-way temporary traffic control zone is short enough to allow visibility from one end to the other, traffic may be controlled by either a single flagger or by a flagger at each end of the section. When a single flagger is used, the flagger should be stationed on the shoulder opposite the obstruction or work space, or in a position where good visibility and traffic control can be maintained at all times. When good visibility and traffic control cannot be maintained by one flagger station, traffic may be controlled by a flagger at each end of the section. One of the flaggers should be designated as the coordinator. Flaggers should be able to communicate orally or with signals. These signals should not be mistaken for flagging signals. The use of radios may also be desirable even though visual contact is possible.

b. Flag Transfer Method

Flag carrying is effective when the route is well defined. It should be employed only when the one-way traffic is confined to a relatively

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short length of road, usually not more than 1 mile in length.

The driver of the last vehicle proceeding into the one-lane section is given a red flag (or other token) and instructed to deliver it to the flagger at the other end. The opposite flagger, upon receipt of the flag, then knows that it is safe to allow traffic to move in the other direction. The flag being carried should always be clean and dry. A variation of this method is the use of an "official" car that always follows the last vehicle proceeding through the section. The use of an official car eliminates the possibility of loss of the flag.

c. Pilot Car Method

A pilot car is used to guide a queue of vehicles through a normally complex temporary traffic control zone or detour. Its operation must be coordinated with flagging operations or other controls at each end of the one-lane section.

The pilot car should have the name of the contractor or contracting authority prominently displayed. The PILOT CAR sign (G20-4) shall be mounted at a conspicuous location on the rear of the vehicle.

Two or more pilot cars may be used to guide two-way traffic through a particularly complex detour.

d. Temporary Traffic Signal Method

Traffic signals may be used to control vehicular traffic movements in temporary traffic control zones. Traffic signals should also be considered for half-width bridge reconstruction on low- to moderate-volume highways. Typical applications include highway or street intersections with a temporary haul road or equipment crossing and through areas requiring alternating one-way traffic operations.

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e. Stop or Yield Control Method

A yield or stop sign may be installed on low-volume, two-lane roads where one side of the roadway is closed and the other side must serve both directions. The side that is closed should yield to or stop for oncoming traffic on the side that is open. The approach to the side that is not closed must be visible (for a distance equal to the safe-passing sight distance for that approach) to the driver who must yield or stop. See section 3B-5, Warrants for No-Passing Zones at Curves.

6C-6. TRANSIT CONSIDERATIONS

Provision for effective continuity of transit service needs to be incorporated into the temporary traffic control planning process. Oftentimes, public transit buses cannot efficiently be detoured in the same manner as other vehicles (particularly for short-term maintenance projects). On transit routes, the TCP shall provide for features such as temporary bus stops, pull-outs, and waiting areas for transit patrons.

6D. PEDESTRIAN AND WORKER SAFETY

6D-1. PEDESTRIAN CONSIDERATIONS

There are three threshold considerations in planning for pedestrian safety in temporary traffic control zones on highways and streets:

- Pedestrians should not be led into direct conflicts with work site vehicles, equipment, or operations.
- Pedestrians should not be led into direct conflicts with mainline traffic moving through or around the work site.
- Pedestrians should be provided with a safe, convenient travel path that replicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

In accommodating the needs of pedestrians at work sites, it should always be remembered that the range of pedestrians that can be expected is very wide, including the blind, the hearing impaired, and those with walking handicaps. All

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pedestrians need protection from potential injury and a smooth, clearly delineated travel path.

Therefore, every effort should be made to separate pedestrian movement from both work site activity and adjacent traffic. Whenever possible, signing should be used to direct pedestrians to safe street crossings in advance of an encounter with a temporary traffic control zone. Signs should be placed at intersections so that pedestrians, particularly in high-traffic-volume urban and suburban areas, are not confronted with mid-block work sites that will induce them to skirt the temporary traffic control zone or make a mid-block crossing. It must be recognized that pedestrians will only infrequently retrace their steps to make a safe crossing. Consequently, ample advance notification of sidewalk closures is critically important. Refer to figures TA-28 and TA-29, section 6H-3 for typical traffic control device usage and techniques for pedestrian movement through work areas.

When pedestrian movement through or around a work site is necessary, the aim of the engineer should be to provide a separate, safe footpath without abrupt changes in grade or terrain. Judicious use of special warning and control devices may be helpful for certain difficult work area situations. These include rumble strips, changeable message signs, hazard identification beacons, flags, and warning lights. Flagger activated audible warning devices may be used to alert pedestrians of the approach of erratic vehicles. Also, whenever it is feasible, closing off the work site from pedestrian intrusions is preferable to channelizing pedestrian traffic along the site solely with temporary traffic control devices such as cones, tubular markers, barricades, or drums. If the possibility of vehicle impact is very low, chain link or other suitable fencing, placed well away from traffic, is acceptable. Solid fencing with plywood, however, can create sight distance restrictions at intersections and at work site access cuts. Care must be taken not to create fenced areas that are vulnerable to splintering or fragmentation by vehicle impacts. Similarly, temporary traffic control devices used to delineate a temporary traffic control zone pedestrian walkway must be lightweight and, when struck, present a minimum threat to pedestrians, workers, and impacting vehicles. Only minimally necessary ballasting with safe, lightweight materials should be used with these devices.

Movement by work vehicles and equipment across designated pedestrian paths should be minimized and, when necessary, should be controlled by flaggers or temporary traffic control. Cuts into work areas across pedestrian walkways should be kept to a minimum, because they often create unacceptable changes in grade and rough or muddy terrain. Pedestrians cannot be

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expected to traverse these areas willingly. They will tend to avoid the cuts by attempting non-intersection crossings.

At work sites of significant duration, especially in urban areas with high pedestrian volumes, and where falling debris is a concern (such as work on overhead structures), a canopied walkway is frequently needed to protect pedestrians from falling debris. These covered walkways should be sturdily constructed and adequately lit for nighttime use.

In places where pedestrians are judged especially vulnerable to impact by errant vehicles, all foot traffic should be separated and protected by longitudinal barrier systems. Where a barrier is clearly needed, it should have sufficient strength and low deflection characteristics, to keep vehicles from intruding into the pedestrian space. Further, short, noncontinuous segments of longitudinal systems, such as concrete barriers, must be avoided because they nullify the containment and redirective capabilities of the design, increase the potential for serious injury to both vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained impact attenuators. With regard to concrete barriers in particular, it is very important to ensure that adjacent segments are properly joined to effect the overall strength required for the system to perform properly.

It has been determined through study and experience that vertical curbs cannot prevent vehicle intrusions onto sidewalks. As a consequence, normal vertical curbing is not a satisfactory substitute for positive barriers when these are clearly needed. Similarly, contractor-constructed wooden railings, chain-link fencing with horizontal pipe runs, and similar systems placed directly adjacent to vehicle traffic are not acceptable substitutes for crashworthy positive barriers; when struck, they are dangerous to vehicle occupants, workers, and pedestrians. In many instances, temporary positive barriers may be necessary to prevent pedestrians from unauthorized movements into the active work area and to prevent conflicts with traffic by eliminating the possibility of mid-block crossings.

If a high potential exists for vehicle incursions into the pedestrian space, judgment must be exercised as to whether to reroute pedestrians or use barriers. Normally, standard traffic control devices can satisfactorily delineate a temporary traffic control zone pedestrian path, but fail-safe channelization can never be guaranteed with these devices because of the gaps between them. Tape, rope, or plastic

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chain strung between devices can help discourage pedestrian movements off the designated pathway.

Good engineering judgment in each temporary traffic control zone situation should readily determine the extent of pedestrian needs. The engineer in charge of traffic control for temporary traffic control zones should provide both a sense of security and safety for pedestrians walking past work sites and consistent, unambiguous channelization to maintain foot traffic along the desired travel paths.

6D-2. WORKER SAFETY CONSIDERATIONS

Of equal importance to the safety of the public traveling through the temporary traffic control zone is the safety of the worker performing the many varied tasks within the work site. Work areas present temporary and constantly changing conditions that are unexpected by the traveler. Further, these work area conditions almost always present situations that are more confusing for the driver. This creates an even higher degree of vulnerability for the personnel on or near the roadway.

Following the Fundamental Principles noted above in Section 6B will usually provide the degree of control and traffic operation that will bring about safe conditions for the worker. Of particular importance is maintaining work areas with traffic flow inhibited as little as possible, providing standard and clear traffic control devices that get the driver's attention and provide positive direction.

Below are key elements of traffic control management that should be considered in any procedure for assuring worker safety:

- Training—All workers should be trained in how to work next to traffic in a way that minimizes their vulnerability. In addition, workers with specific traffic control responsibilities should be trained in traffic control techniques, device usage, and placement.

- Worker Clothing—Workers exposed to traffic should be attired in bright, highly visible clothing similar to that of flaggers.

- Barriers—Barriers should be placed along the work space depending on such factors as lateral clearance of workers from adjacent traffic, speed of traffic, duration of operations, time of day, and volume of traffic.

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- Speed Reduction—In highly vulnerable situations, consideration should be given to reducing the speed of traffic through regulatory speed zoning, funneling, use of police, lane reduction, or flaggers.

- Use of Police—In highly vulnerable work situations, particularly those of relatively short duration, stationing police units heightens the awareness of passing traffic and will likely cause a reduction in travel speed.

- Lighting—For nighttime work, lighting the work area and approaches may allow the driver better comprehension of the requirements being imposed. Care should be taken to ensure that the lighting does not cause blinding.

- Special Devices—Judicious use of special warning and control devices may be helpful for certain difficult work area situations. These include rumble strips, changeable message signs, hazard identification beacons, flags, and warning lights. Flagger activated audible warning devices may be used to alert workers to the approach of erratic vehicles. Misuse and overuse of special devices/techniques can greatly lessen their effectiveness.

- Public Information—Improved driver performance may be realized through a well-prepared and complete public relations effort that covers the nature of the work, the time and duration of its execution, and its anticipated effects upon traffic and possible alternate routes and modes of travel. Such programs have been found to result in a significant drop in traffic; that reduces the possible number of conflicts and may allow a temporary lane closing for additional buffer area.

- Road Closure—If alternate routes are available to handle detoured traffic, the road may be closed temporarily during times of greatest worker hazard—which, in addition to offering maximum worker safety, may facilitate quicker project completion and thus further reduce worker vulnerability.

Like other provisions of work area safety set forth in this part of the MUTCD, the various traffic control techniques must be applied by qualified persons after appropriate engineering studies and with sound engineering judgment and common sense.

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6E. HAND-SIGNALING CONTROL

6E-1. FUNCTION

The primary function of traffic control procedures is to move vehicles and pedestrians safely and expeditiously through or around temporary traffic control zones while protecting on-site workers and equipment.

6E-2. QUALIFICATIONS FOR FLAGGERS

Because flaggers are responsible for public safety and make the greatest number of public contacts of all highway workers, they should have the following minimum qualifications:

- Sense of responsibility for the safety of the public and workers
- Training in safe traffic control practices
- Average intelligence
- Good physical condition, including sight and hearing
- Mental alertness and the ability to react in an emergency
- Courteous but firm manner
- Neat appearance

6E-3. HIGH-VISIBILITY CLOTHING

For daytime work, the flagger's vest, shirt, or jacket shall be orange, yellow, strong yellow green or fluorescent versions of these colors. For nighttime work, similar outside garments shall be retroreflective. The retroreflective material shall be orange, yellow, white, silver, strong yellow-green, or a fluorescent version of one of these colors and shall be visible at a minimum distance of 1,000 feet. The retroreflective clothing shall be designed to identify clearly the wearer as a person and be visible through the full range of body motions.

Uniformed law enforcement officers may be used as flaggers in some locations, such as an urban intersection, where enforcement of traffic movements is important. Uniformed law enforcement officers may also be used on freeways where traffic is channelled around work sites and it is necessary to assure that advisory and regulatory speeds are

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being enforced. For nighttime work and in low-visibility situations, a retroreflective garment as described above should be worn.

6E-4. HAND-SIGNALING DEVICES

Hand-signaling devices, such as STOP/SLOW paddles, lights, and red flags are used to control traffic through temporary traffic control zones. The STOP/SLOW paddle, which gives drivers more positive guidance than red flags, should be the primary hand-signaling device. The standard STOP/SLOW sign paddle shall be 18 inches square with letters at least 6 inches high. A rigid handle should be provided. This combination sign should be fabricated from light semirigid material, and shall have an octagonal shape. The background of the STOP face shall be red with white letters and border. To improve conspicuity, the STOP/SLOW paddles may be supplemented by one or two symmetrically positioned alternately flashing white high-intensity lamps on each side. The background of the SLOW face shall be orange with black letters and border. When used at night, the STOP/SLOW paddle shall be retroreflectorized in the same manner as signs.

Flag use should be limited to emergency situations and at low-speed and/or low-volume locations which can best be controlled by a single flagger. Flags used for signaling shall be a minimum of 24 inches square, made of a good grade of red material, and securely fastened to a staff about 3 feet long. The free edge should be weighted so the flag will hang vertically, even in heavy winds. When used at night, flags shall be retroreflective red.

6E-5. HAND-SIGNALING PROCEDURES

STOP/SLOW paddle and flag use are illustrated in figure VI-4. The following methods of signaling with STOP/SLOW paddles should be used:

- To Stop Traffic—The flagger shall face traffic and extend the STOP sign paddle in a stationary position with the arm extended horizontally away from the body. The free arm should be raised with the palm toward approaching traffic.

- To Direct Stopped Traffic to Proceed—The flagger shall face traffic with the SLOW paddle held in a stationary position with the arm extended horizontally away from the body. The flagger should motion with the free hand for traffic to proceed.

- To Alert or Slow Traffic—The flagger shall face traffic with the SLOW sign paddle held in a

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stationary position with the arm extended horizontally away from the body. The flagger may motion up and down with the free hand, palm down, indicating that the vehicle should slow down.

The following methods of signaling with a flag should be used:

- To Stop Traffic—The flagger shall face traffic and extend the flag staff horizontally across the traffic lane in a stationary position, so that the full area of the flag is visible hanging below the staff. The free arm should be raised with the palm toward approaching traffic.

- To Direct Stopped Traffic to Proceed. The flagger shall face traffic with the flag and arm lowered from view of the driver. With the free hand, the flagger should motion traffic to proceed. Flags shall not be used to signal traffic to proceed.

- To Alert or Slow Traffic. The flagger shall face traffic and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down, without raising the arm above a horizontal position.

6E-6. FLAGGER STATIONS

Flagger stations shall be located far enough ahead of the work space so that approaching traffic has sufficient distance to stop before entering the work space. Table VI-1, *Guidelines for length of longitudinal buffer space*, may be used for locating flagger stations in advance of the work space. This distance is related to approach speeds, friction factors, and pavement and tire conditions. These distances may be increased for downgrades.[2]

The flagger should stand either on the shoulder adjacent to the traffic being controlled or in the barricaded lane. At a "spot" obstruction, a position may have to be taken on the shoulder opposite the barricaded section to operate effectively. A flagger should stand only in the lane being used by moving traffic after traffic has stopped, and the flagger needs to be visible to other traffic or to communicate with drivers. Because of the various roadway geometrics, flaggers should be clearly visible to approaching traffic at all times. For this reason the flagger should stand alone.

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[2]Table III-2. A Policy on Geometric Design of Highways and Streets, AASHTO, 1990, p. 125.

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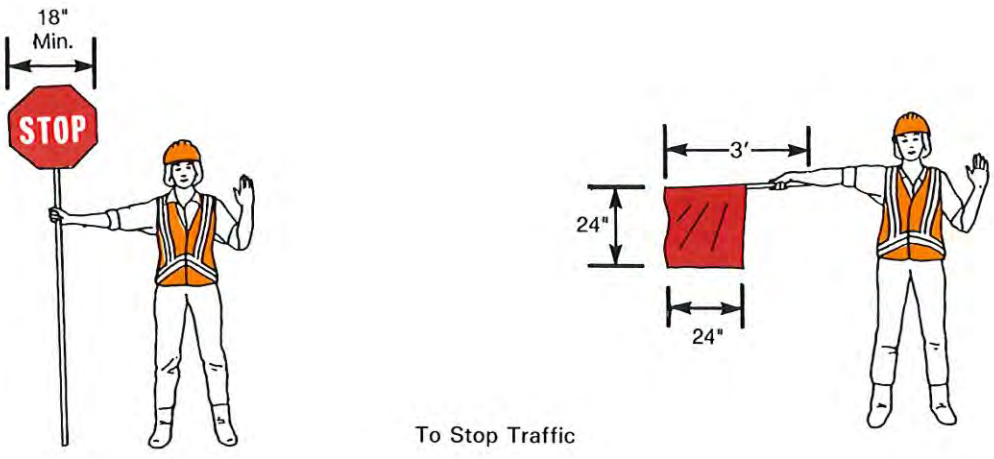
PREFERRED METHOD | EMERGENCY USE ONLY

Paddle | Flag



To Stop Traffic

Traffic Proceed

To Alert and
Slow Traffic

Figure VI-4. Use of hand signaling devices by flagger.

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Other workers should not be permitted to congregate around the flagger station. The flagger should be stationed far enough ahead of the work force to warn them (for example with horns,whistles etc.) of approaching danger, such as vehicles out of control.

Flagger stations should be visible far enough ahead to permit all vehicles to stop. Table VI-1, *Guidelines for length of longitudinal buffer space*, may be used in selecting the location of flaggers. This distance is related to approach speeds, friction factors, and pavement and tire conditions, These distances may be increased for downgrades.[3] These distances are calculated in a manner similar to those calculated in the first paragraph of 6E-6. Flagger stations should be preceded by proper advance warning signs. Under certain geometric and traffic situations, more than one flagger station may be required for each direction of traffic. At night, flagger stations should be illuminated.

At two-way, unusually low-volume and/or unusually low-speed short lane closings where adequate sight distance is available for the safe handling of traffic, the use of one flagger may be sufficient.

6F. TYPES OF DEVICES

The design and applications of traffic control devices used in temporary traffic control zones are described in this chapter. A traffic control device is a sign, signal, marking or other device placed on or adjacent to a street or highway (by authority of a public body or official having jurisdiction) to regulate, warn, or guide traffic. Specific crashworthy information on devices described in this chapter can be found in the AASHTO Roadside Design Guide.[4]

6F-1. SIGNS

Temporary traffic control zone signs convey both general and specific messages by means of words or symbols and have the same three categories as all traffic signs: namely, regulatory signs, warning signs, and guide signs. The colors for regulatory signs shall follow the standard for regulatory signs in section 2B-3. Warning signs in temporary traffic

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[3]Table III-2. A Policy on Geometric Design of Highways and Streets, AASHTO, 1990, p. 125.

[4]AASHTO, 44 North Capitol Street, N.W., Suite 225, Wahington, D.C. 20001.

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control zones shall have a black legend on an orange background. Yellow warning signs within the traffic control zone which are still applicable may remain in place. Colors for guide signs follow the standard in section 2D-3, except for special information signs as noted below in section 6F-1C.

Where the color orange is specified, fluorescent red-orange or fluorescent yellow-orange colors may be used. The fluorescent versions of orange provide higher conspicuity than standard orange, especially during twilight.

All signs used at night shall be either retroreflective, with a material that has a smooth, sealed outer surface, or illuminated to show similar shape and color both day and night. Sign illumination may be either internal or external. Roadway lighting does not meet the requirements for sign illumination.

Standard orange flags or Type B high-intensity flashing warning lights may be used in conjunction with signs. However, they must not block the sign legend.

The dimensions of signs shown herein are for standard sizes, which may be increased wherever necessary for greater legibility or emphasis. On secondary highways and city streets, smaller signs may be used if authorized by lawful authority. Deviations from standard sizes as prescribed herein shall be in 6-inch increments. Sign design details are contained in Standard Highway Signs.[5]

As a general rule, signs should be located on the right-hand side of the roadway. When special emphasis is needed, signs may be placed on both the left and right sides of the roadway. Signs may be mounted on portable supports placed within the roadway itself. Signs, although ordinarily mounted on posts, may also be mounted on or above barricades.

Guidelines for height and lateral clearance of temporary post-mounted roadside signs are shown in figure VI-5. Signs erected at the side of the road should be mounted at a height of at least 7 feet, measured from the bottom of the sign to the near edge of the pavement. The height to the bottom of a secondary sign mounted below another sign may be 1 foot less than the appropriate height specified above.

Methods of mounting signs other than on posts are illustrated in figure VI-6. Signs may be mounted on portable

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[5]Standard Highway Signs, Stock No. 950-044-00000-4. Available from the Government Printing Office, Superintendent of Documents, Washington D.C. 20402. Telephone: 202-783-3238.

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supports for short-term, short-duration, and mobile conditions (see section 6G-2). Signs mounted on Type III barricades should not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. Unprotected sign systems should be crashworthy (refer to the Roadside Design Guide, chapter Nine, for additional guidance).[6] The bottom of signs mounted on barricades or temporary supports shall be no less than 1 foot above the traveled way.

For the best mobility of maintenance operations, a large sign may be mounted on a maintenance vehicle stationed in advance of the work or moving along with it. This may be either the work vehicle or the protection vehicle. A mobile sign display may be mounted on a trailer.

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[6]AASHTO, 44 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

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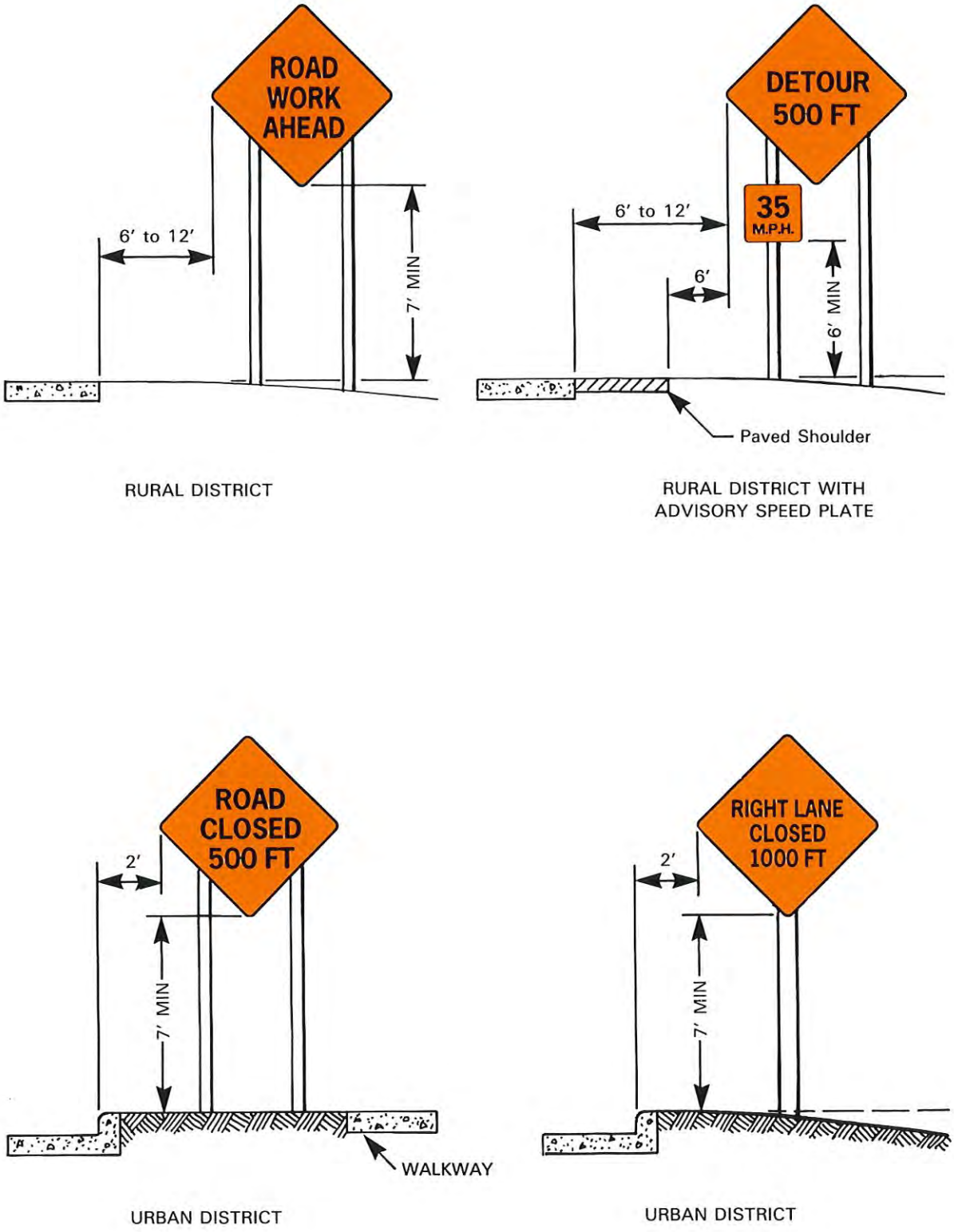

Figure VI-5. Height and lateral location of signs – Typical installation.

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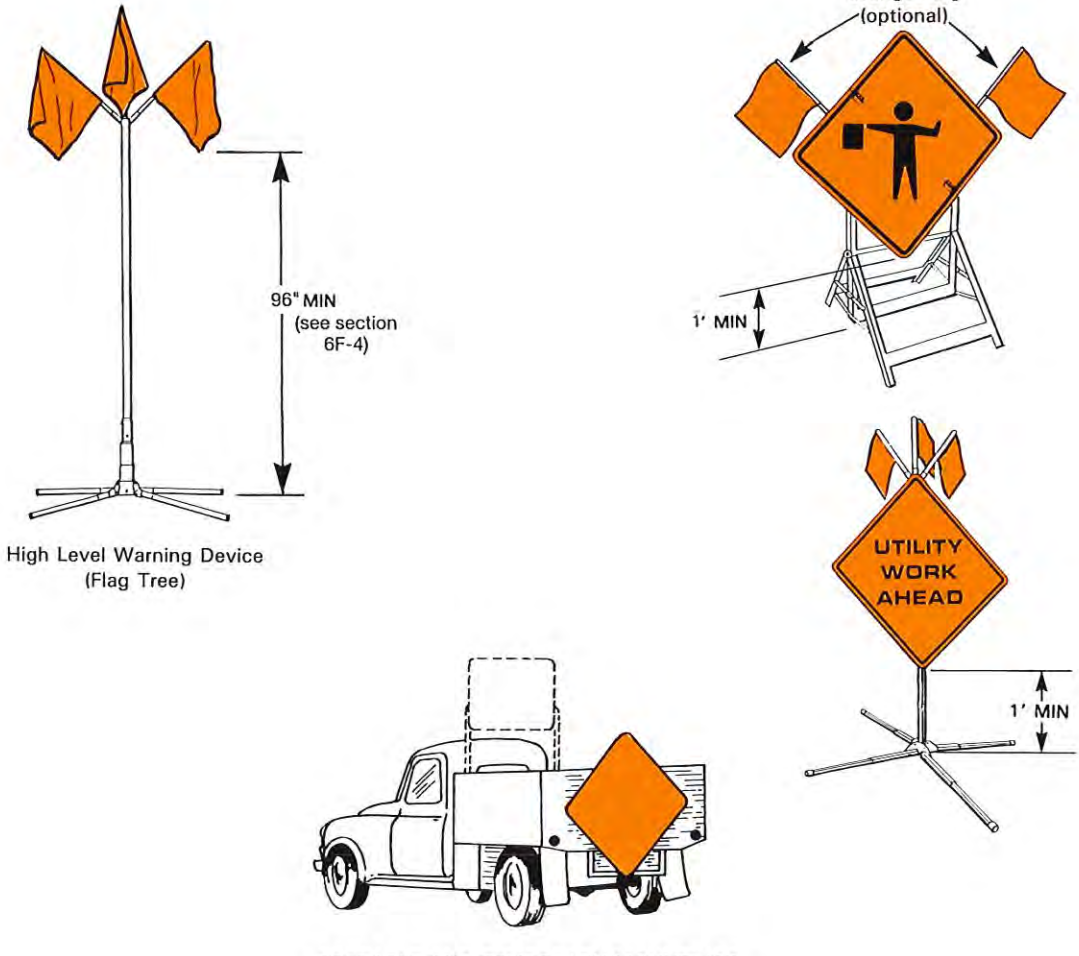

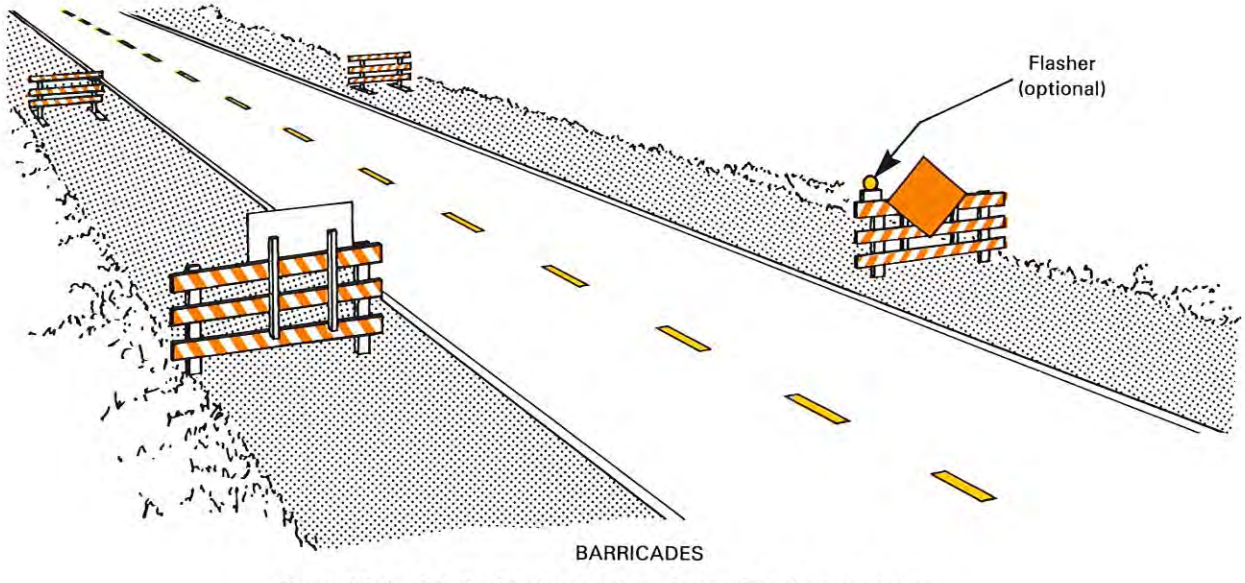

Figure VI-6. Methods of mounting signs other than on posts.

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Signs used in temporary traffic control zones are moved frequently, loaded and unloaded from trucks, and in general receive much harsher treatment than permanent signs. For this reason, particular attention must be given to maintaining signs properly for cleanliness, visibility, and correct positioning. Signs are excessively worn, scratched, bent, or have lost a significant amount of retroreflectivity should be promptly replaced.

a. Regulatory Signs

(1) Authority

Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. Because regulatory signs impose legal obligations on all drivers, they shall be authorized by the public body or official having jurisdiction and shall conform to section 2B of this manual.

(2) Design

Regulatory signs are generally rectangular, with a black legend and border on a white background. Exceptions include the STOP sign, the YIELD sign, the DO NOT ENTER sign, the WRONG WAY sign, and the one-way arrow sign. The one-way arrow sign may be either a horizontal or vertical rectangular plate. Regulatory signs are illustrated in figures VI-7a and VI-7b. Design details for all regulatory signs are given in part II of this manual and in the Standard Highway Signs book.[7]

[7]Standard Highway Signs, Stock No. 950-044-00000-4. Available from the U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402. Telephone: 202-783-3238.

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R1-1
30″x30″

R1-2
36″x36″x36″

R2-1
24″x30″

R2-5a
24″x30″

R2-5b
24″x30″

R2-5c
24″x30″

R3-1
24″x24″

R3-2
24″x24″

R3-3
24″x24″

R3-4
24″x24″

R3-5
30″x36″

R3-6
30″x36″

R3-7
30″x30″

R3-8
30″x30″

R4-1
24″x30″

R4-2
24″x30″

Figure VI-7a. Commonly used regulatory signs.

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R4-7
24″x30″

R5-1
30″x30″

R5-1a
36″x24″

R6-2
18″x24″

R6-1
36″x12″

R8-3a
24″x24″

Figure VI-7b. Commonly used regulatory signs.

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(3) Application

If temporary traffic control zones require regulatory measures different from those normally in effect, the existing permanent regulatory devices shall be temporarily removed or covered and superseded by the appropriate temporary regulatory signs and shall follow applicable ordinances or statutes of the jurisdiction, as well as comply with the sign design standards of the MUTCD.

(4) ROAD (STREET) CLOSED Sign (R11-2)

The ROAD (STREET) CLOSED sign may be used where the roadway is closed to all traffic except contractors' equipment or officially authorized vehicles and may be accompanied by appropriate detour signing. The sign should be erected at or near the center of the roadway on or above a Type III barricade that closes the roadway (section 6F-5F). The sign should have a minimum size of 48 inches by 30 inches. The words BRIDGE OUT or BRIDGE CLOSED may be substituted for ROAD CLOSED, where applicable. The ROAD (STREET) CLOSED sign shall not be used where traffic is maintained or where the actual closing is some distance beyond this sign.

R11-2
48"x30"

(5) LOCAL TRAFFIC ONLY Signs (R11-3, R11-4)

The LOCAL TRAFFIC ONLY signs should be used where through traffic must detour to avoid a closing some distance beyond the sign, but where local traffic can move up to point of closure. The sign shall carry the legend ROAD CLOSED [10] MILES AHEAD—LOCAL TRAFFIC ONLY or, optionally for urban use, ROAD (STREET) CLOSED TO THRU TRAFFIC, and should be accompanied by appropriate warning and detour signing. The words BRIDGE OUT or BRIDGE CLOSED may be substituted for ROAD CLOSED where applicable.

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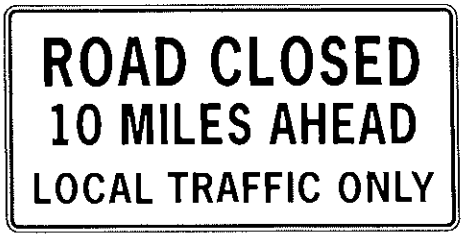
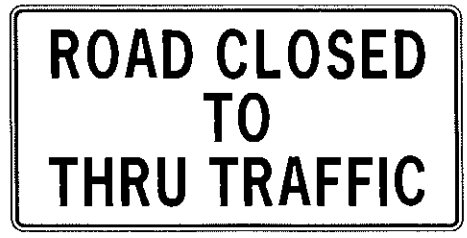


R11-3
60"x30"

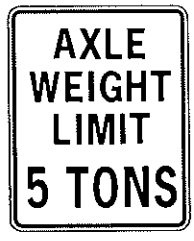


R11-4
60"x30"

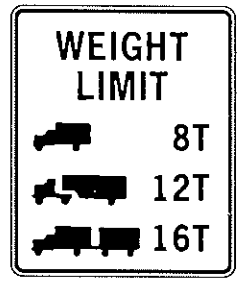
(6) WEIGHT LIMIT Signs (R12-1, R12-2, R12-5)

A WEIGHT LIMIT sign shows the gross weight or axle weight that can be permitted on the roadway or bridge. Weight restrictions should be consistent with state or local regulations and shall not be imposed without the approval of the authority having jurisdiction over the highway. When weight restrictions are imposed, a marked detour should be provided for vehicles weighing more than the limit posted.

R12-1
24"x30"



R12-2
24"x30"



R12-5
30"x36"

(7) Special Regulatory Signs

Special word message regulatory signs may be needed based on an engineering analysis. The sign should conform to the requirements of color, shape, and alphabet size and series. The sign message should be brief, legible, and clear. Regulatory speed limits are established by law or regulation. Section 2B of this manual should be consulted before temporary traffic control zone regulatory speed limits are established.

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b. Warning Signs

(1) Function

Temporary traffic control zone warning signs notify drivers of general or specific conditions on or adjacent to a roadway.

(2) Design and Application

With some exceptions, warning signs shall be diamond-shaped with a black symbol or message on an orange background. Mounting or space considerations may justify a change from the standard diamond shape, but such variations require prior approval of the highway authority.

Warning signs developed exclusively and used for incident management shall have an orange background. However, in emergencies, available signs having yellow backgrounds may be used if orange signs are not readily available.

The standard size for each warning sign prescribed in this section is shown with the illustration accompanying the specification. Where roadway or traffic conditions require greater emphasis, larger signs should be used, with symbol or legend enlarged approximately in proportion to outside dimensions. Sign sizes for various type facilities can be found in Standard Highway Signs document.[8] (See section 1A-7.)

Where any part of the roadway is obstructed or closed, advance warning signs are required to alert traffic well in advance of these obstructions or restrictions. These signs may be used singly or in combination. Because of their importance, they shall have a standard size of 48 inches square and shall be the standard diamond shape for warning signs, except as provided above. Signs larger than 48 inches square may be used for additional emphasis of the temporary traffic control zone.

Where speeds and volumes are moderately low, a minimum size of 36 inches square may be used for advance warning signs, if they have a minimum letter size of 5 inches.

On secondary roads or city streets where speeds are very low, signs smaller than the standard size, but not less than

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[8]Standard Highway Signs, Stock No. 950-044-00000-4, available from the U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402. Telephone: 202-783-3238.

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24 inches square, may be used for warning signs having short word messages or clearly understood symbols.

Where distances are not shown on warning signs as part of the message, a separate panel with the distance legend may be mounted immediately below the sign on the same support.

(3) Spacing of Warning Signs Covered in Section 6H-3 Typical Application Diagrams

Where highway conditions permit, warning signs should be placed at varying distances in advance of the work area, depending on the roadway type, condition, and speed. Where a series of two or more warning signs is used, the closest sign to the work area should be placed approximately 200 feet away for low-speed urban streets to 1,000 feet away or more for expressways and freeways.

Table VI-3 presents the suggested spacing of warning signs for four general roadway types for use in section 6H-3, Typical Application Diagrams.

Table VI-3. Suggested advance warning sign spacing

Road type	Distance between signs		
	A	B	C
Urban (low speed*)	200	200	200
Urban (high speed*)	350	350	350
Rural	500	500	500
Expressway/Freeway	1,000	1,600	2,600

*** Speed category to be determined by State highway agency in cooperation with local jurisdictions.**

In table VI-3, the column headings "A", "B", and "C" are the dimensions for warning sign spacings for use in section 6H-3, Typical Application Diagrams. The dimensions are for marking the locations of warning signs relative to the transition or point of restriction. Sign placement distances suggested in Table II-1-A are not applicable for the A, B, or C (table VI-3) distances between signs in section 6H-3.

- The "A" dimension is for the sign nearest the transition or point of restriction.
- The "B" dimension is for the next sign upstream of the transition or restriction.

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- The "C" dimension is for the first sign (in a three-sign series) that the driver encounters in a temporary traffic control zone.

(4) Other Approach Warning Signs

Certain conditions require other advance warning signs, such as limited sight distance or because an obstruction may require a motorist to stop. There are no specified standards for such signs. The determination of the sign or signs to be used shall be based on an engineering study using the following sections as guidelines. As an alternative to a specific distance on these advance warning signs, the word AHEAD may be used.

(5) Application of Warning Signs for Maintenance, Minor Road Work, and Utility Sites

At many maintenance, minor road work, and utility sites, particularly on lightly traveled roads, the sequence of advance warning signs prescribed for major road work may not be needed. The signs described in the following sections wi11 usually provide sufficient advance warning in such situations, either by themselves or with other advance warning signs.

Maintenance or minor road work can occur within the temporary traffic control zone limits of a major project. Maintenance or minor road work warning signs, which be needed when traffic is permitted through such zones. Maintenance and minor road work signing and traffic control should be coordinated with appropriate authorities so that drivers are not confused or misled by additional traffic control devices.

(6) ROAD (STREET) WORK Sign (W20-1)

The ROAD (STREET) WORK sign should be located ahead of the work space or detour, to serve as a general warning of obstructions or restrictions. It carries the legend ROAD (STREET) WORK (1,500) FT or ROAD (STREET) WORK (1/2) MILE. It may be used in conjunction with appropriate distance legends, or with other warning signs.

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W20-1
48"x48"

(7) DETOUR Sign (W20-2)

The DETOUR sign is used ahead of a detour that directs traffic onto another highway in order to bypass the temporary traffic control zone. It carries the legend DETOUR [1,000] FT or DETOUR [1/2] MILE. It may be used in conjunction with appropriate legends or with other warning signs.

(8) ROAD (STREET) CLOSED Sign (W20-3)

The ROAD (STREET) CLOSED sign is used ahead of that point where a highway is closed to all traffic or to all but local traffic. If carries the legend ROAD (STREET) CLOSED [1,000] FT or ROAD (STREET) CLOSED [1/4] MILE. It may be used in conjunction with appropriate legends or with other warning signs.

W20-2
48"x48"

W20-3
48"x48"

(9) ONE LANE ROAD Sign (W20-4)

The ONE LANE ROAD sign should be used ahead of that point where traffic in both directions must use a common single lane. It carries the legend ONE LANE ROAD [1,000] FT or ONE LANE ROAD [1/4] MILE. The sign may be used in conjunction with appropriate legends or with other warning signs.

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If the affected one-lane roadway is not visible from one end to the other, or if the traffic is such that simultaneous arrivals at both ends occur frequently, flagging procedures or signal control should be used to control alternate traffic flows.

(10) LANE CLOSED Sign (W20-5)

The LANE CLOSED sign is used before that point where one lane of a multiple-lane roadway is closed. It carries the legend RIGHT (LEFT) LANE CLOSED [1,000] FEET or RIGHT (LEFT) LANE CLOSED [1/4] MILE. The sign may be used in conjunction with appropriate legends or with other warning signs.

W20-4
48"x48"

W20-5
48"x48"

(11) FLAGGER Sign (W20-7a)

The FLAGGER symbol sign (W20-7a) should be used before any point where a flagger is stationed to control traffic. A distance legend may be displayed on a supplemental plate below the symbol sign. The sign may be used in conjunction with appropriate legends or with other warning signs, such as W20-7b, BE PREPARED TO STOP.

The FLAGGER word message sign (W20-7) with distance legends may be substituted for the flagger symbol sign (W20-7a).

The FLAGGER sign shall be removed, covered, or turned to face away from traffic when the flagger is not at the station.

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W6-3
48"x48"

(12) TWO-WAY TRAFFIC Sign (W6-3)

When one roadway of a normally divided highway is closed, the TWO-WAY TRAFFIC sign should be used at the beginning of the closing and at intervals to remind drivers that they are on a two-way highway with opposing traffic.

W20-7a
48"x48"
SUPPLEMENTAL PLATE
24"x18"

(13) WORKERS Sign (W21-1a)

A WORKERS sign may be used to alert drivers of workers in or near the roadway. The W21-1 WORKERS word message sign may be used as an alternative to the W21-1a workers symbol sign.

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(14) FRESH OIL Sign (W21-2)

The FRESH OIL (TAR) sign should be placed ahead of the last exit to warn drivers that resurfacing has rendered the pavement temporarily slippery and that splashing may occur.

(15) ROAD MACHINERY Sign (W21-3)

The ROAD MACHINERY sign may be used to warn of heavy equipment operating in or next to the roadway.

(16) SHOULDER WORK Sign (W21-5)

The SHOULDER WORK sign may be used to warn of maintenance, reconstruction, or utility operations on the shoulder, where the traveled way is unobstructed.

(17) SURVEY CREW Sign (W21-6)

The SURVEY CREW sign may be used to warn of survey crews working in or next to the roadway.

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W21-1A
36"x36"

W21-2
30"x30"

W21-3
36"x36"

W21-5
30"x30"

W21-6
30"x30"

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(18) Signs for Blasting Areas

Radio frequency (RF) energy can cause the premature firing of electric detonators (blasting caps) used in temporary traffic control zones or blasting zones. Drivers must be warned to turn off mobile radio transmitters and cellular telephones. The Institute of Makers of Explosives publishes information on this hazard and guidelines for safe operations.[9]

A sequence of signs should be used to direct operators of mobile radio equipment to turn off transmitters in a blasting area. A minimum safe distance of 1,000 feet should be used for warning sign placement. These signs shall be prominently displayed and covered or removed when there are no explosives in the area or the area is otherwise secured.

(18a) BLASTING ZONE Sign (W22-1)

The BLASTING ZONE AHEAD sign should be used in advance of any work space where explosives are being used. The TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES and END BLASTING ZONE signs shall be used in sequence with this sign.

(18b) TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES Sign (W22-2)

The TURN OFF 2-WAY RADIO AND CELLULAR TELEPHONES sign should follow the BLASTING ZONE AHEAD sign and is placed at least 1,000 feet before the beginning of the blasting zone.

(18c) END BLASTING ZONE Sign (W22-3)

The END BLASTING ZONE sign shall be placed a minimum of 1,000 feet past the blasting zone, either with or preceding the END ROAD WORK sign.

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[9]Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps), Safety Library Publication No. 20. Institute of Makers of Explosives, 1120 19th St., N.W. Suite 310, Washington, D.C. 20036-3605. Telephone 202-429-9280.

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W22-1
48"x48"

W22-2
42"x36"

W22-3
42"x36"

(19) SHOULDER DROP-OFF Sign (W8-9a)

The SHOULDER DROP-OFF sign should be used when a shoulder drop-off exceeds 3 inches in height and is not protected by a portable barrier.

W8-9a
36"x36"

(20) UNEVEN LANES Sign (W8-11)

The UNEVEN LANES sign should be used during operations that create a difference in elevation between adjacent lanes.

W8-11
36"x36"

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(21) NO CENTER STRIPE Sign (W8-12)

The NO CENTER STRIPE sign should be used when the work obliterates the center stripe. This sign should be placed at the beginning of the zone and repeated at 2-mile intervals in long zones to remind the motorist. It should also be used at major connections, traffic generators, and/or at appropriate intervals as determined by the engineer, to advise motorists entering within the zone.

W8-12
36"x36"

(22) Other Warning Signs

The signs pictured in figures VI-8a, VI-8b, and VI-8c may also be used to provide sufficient advance warning, either by themselves or with other advance warning signs.

Besides the warning signs specifically related to temporary traffic control zones, several other warning signs, most of which have been standardized in part II of this MUTCD, may apply in these zones. When used in temporary traffic control zones, warning signs shall have black legends on an orange background.

(23) Advisory Speed Plate (W13-1)

In combination with a warning sign, an advisory speed plate may be used to indicate a recommended safe speed through the temporary traffic control zone. When used with orange temporary traffic control zone signs, this plate shall have a black legend and border on an orange background. It shall not be used with any sign other than a warning sign, nor shall it be used alone. The sign shall be at least 24 inches square in size when used with a sign 36 inches square or larger. Except in emergencies, an advisory speed plate (W13-1) shall not be mounted until the recommended speed is determined by the highway authority.

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W13-1
18"x18"
24"x24"

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W1-1R
30"x30"

W1-2R
30"x30"

W1-3R
30"x30"

W1-4aR
30"x30"

W1-4bR
48"x48"

W1-4cR
48"x48"

W1-6
48"x24"

W1-8
18"x24"

W3-1a
36"x36"

W3-2a
36"x36"

W3-3
36"x36"

W4-1
30"x30"

W4-2
36"x36"

W4-3
36"x36"

W5-1
36"x36"

W5-2
36"x36"

Figure VI-8a. Warning signs used in temporary traffic control zones.

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W5-2a
36"x36"

W5-3
36"x36"

W6-1
36"x36"

W6-2
36"x36"

W7-1
30"x30"

W8-1
30"x30"

W8-2
30"x30"

W8-3
30"x30"

W8-3a
36"x36"

W8-4
30"x30"

W8-5
30"x30"

W8-6
30"x30"

W8-7
30"x30"

W8-8
30"x30"

W8-9
30"x30"

W8-9a
36"x36"

Figure VI-8b. Warning signs used in temporary traffic control zones.

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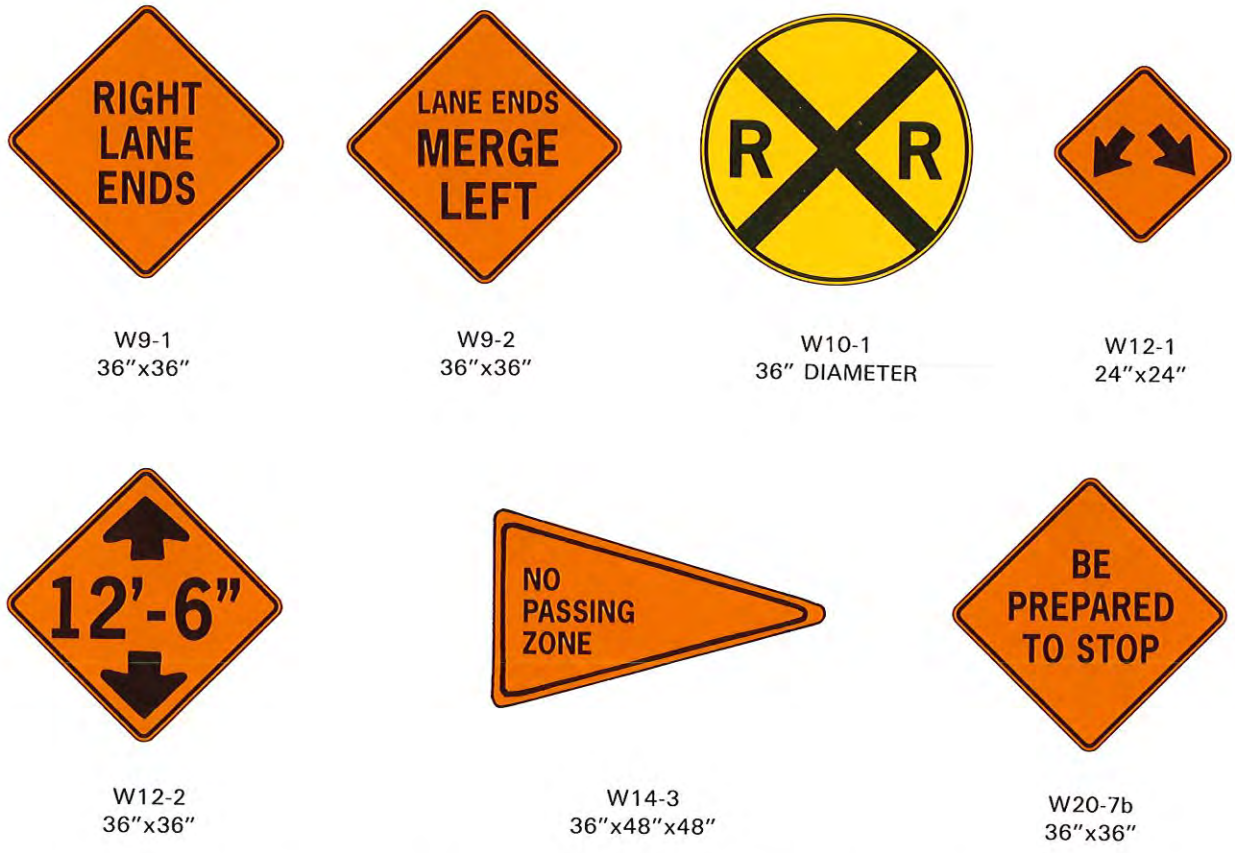

Figure VI-8c. Warning signs used in temporary traffic control zones.

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c. Guide Signs

(1) Function and Design of Guide Signs

Guide signs are essential along streets and roadways to give drivers information that will help them in the most simple, direct manner possible. The design of guide signs is given in part II of this manual.

The following guide signs are required at temporary traffic control zones:

(a) Standard route markings, where temporary route changes are necessary.

(b) Directional signs such as motorist service signing, recreational and cultural interest area signs, tourist-oriented directional signs (TODS), civil defense signing, and street name signs. When used with detour routing, these signs may have a black legend on an orange background.

(c) Special information signs relating to work being done. These signs shall have a black legend on an orange background.

(2) Length of Work Sign (G20-1)

The Length of Work sign should be erected in advance of any temporary traffic control zone of more than 2 miles in length; it carries the legend ROAD WORK NEXT [5] MILES. The distance shall be stated to the nearest whole mile. The sign may be mounted on a Type III barricade. The sign may also be used for jobs of shorter length.

(3) END ROAD WORK Sign (G20-2A)

The END ROAD WORK sign should be placed about 500 feet past the work area. The sign may be erected on the back of a warning sign facing the opposite direction of traffic or on the back of a Type III barricade.

G20-1
60"x24"

G20-2A
48"x24"

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(4) DETOUR signs and Markers (M4-8, -8a, -8b, -9, and -10)

The DETOUR ARROW sign (M4-10) should be used where a detour route has been established because of the closing of a street or highway to through traffic. The sign should normally be mounted just below the ROAD CLOSED (R11-2, R11-3, or R11-4) sign. The DETOUR ARROW sign has a horizontal arrow pointed to the right or left, as required.

Each detour shall be adequately marked with standard temporary route markers and destination signs. The DETOUR marker sign (M4-8), mounted at the top of a route marker assembly, marks a temporary route that branches from a highway, bypasses a section closed by a temporary traffic control zone, and rejoins the highway beyond the temporary traffic control zone.

The DETOUR sign (M4-9) should be used for unnumbered highways, for emergency situations, for periods of short durations, or where, over relatively short distances, traffic may be guided along the detour and back to the desired highway without route markers. A street name sign may be placed above or incorporated in the DETOUR sign to indicate the name of the street being detoured.

The END DETOUR sign (M4-8a or M4-8b) may be used to indicate that the detour has ended. When the END DETOUR sign is used on a numbered highway, the sign should be mounted above a marker after the end of the detour.

M4-8
24"x12"

M4-8a
24"x18"

M4-8b
24"x12"

M4-9R
30"x24"

M4-10R
48"x18"

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(5) PILOT CAR Sign (G20-4)

The Pilot Car sign shall be mounted in a conspicuous position on the rear of a vehicle used for guiding one-way traffic through or around a work space. The legend shall be PILOT CAR—FOLLOW ME. A flagger shall be stationed on the approach to the activity area to stop traffic until the pilot car is available.

G20-4
36"x18"

6F-2. PORTABLE CHANGEABLE MESSAGE SIGNS

a. Design

Portable Changeable Message Signs (PCMS) are traffic control devices with the flexibility to display a variety of messages to fit the needs of road and street authorities. Each message consists of one or more displays. Portable Changeable Message signs are used most frequently on high-density, urban freeways, but have applications on all types of highways where highway alignment, traffic routing problems or other pertinent conditions require advance warning and information.

(1) Components: The components of a PCMS should include message sign panel, control systems, power source, and mounting and transporting equipment.

(a) Message Sign Panel

PCMS cannot always conform to the exact sign shape, color, and dimensions specified in these standards. PCMS should subscribe to the principles established in the manual, and to the extent practicable, with the design (i.e., color, letter size and shape, and borders) and applications prescribed herein. The message sign panel can vary in size and may consist of one, two, or three lines. High-density urban freeways typically use three lines of eight

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characters per line. Each character module shall use, as a minimum, a five wide-pixel by seven high-pixel matrix. The front face of the sign should be covered with a protective material. Element colors for warning messages should be black on a yellow or orange background; for guide messages, white on a green background or black on an orange background; and for regulatory messages, black on a white background. Color reversals are also acceptable.

The signs should be visible from 1/2 mile under ideal day and night conditions. Each sign message should be legible from all lanes, from the sign up to a minimum of 650 feet. In the field, the PCMS should be sited and aligned to optimize driver performance. The message panel should have adjustable flash rates, so that the entire message can be read at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

Under low light level conditions, the sign shall automatically adjust its light source so as to meet the legibility requirements and not impair the drivers' vision.

(b) Control System

The control system shall include the following features:

- A display screen upon which messages can be reviewed before display on the message sign.
- A capability to provide an automatic programmed default message if power failure occurs.
- A backup battery to maintain memory when power is unavailable.

(c) Power Source

The PCMS shall be equipped with a power source and a battery back-up to provide continuing operation when failure of the primary power source occurs.

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(d) Mounting

The mounting of the PCMS shall be such that the bottom of the message sign panel shall be a minimum of 7 feet above the roadway when it is in the operating mode.

b. Application

PCMS have a wide variety of applications in temporary traffic control zones, including roadway or ramp closures, accident or emergency incident management, width restriction information, advisories on roadwork scheduling, traffic management and diversion, warning of adverse conditions, and operation control. PCMS should be used with conventional signs, pavement markings, and lighting.

The primary purpose of PCMS in temporary traffic control zones is to advise the driver of unexpected traffic and routing situations. Some typical applications include the following:

- Where speed of traffic is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions are present
- Where there are changes in alignment or surface conditions
- To provide advance notice of ramp, lane, or roadway closures
- For accident or incident management

PCMS should be placed to be visible from at least 1/2 mile under both day and night conditions. Placement in advance of the temporary traffic control zone or incident should, as much as possible, take into account the following factors:

- PCMS will typically be placed in advance of any other temporary traffic control zone signing and should not replace any required signing.
- Where used for route diversion, PCMS should be placed far enough in advance of the work site to allow traffic ample opportunity to exit the affected highway.

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- PCMS are normally placed on the shoulder of the roadway. However, if practical, placement further from the traveled lane is desirable.

- When two signs are needed to communicate multiple messages, they should be placed on the same side of the roadway, separated by at least 1,000 feet.

PCMS messages should be readily understood by drivers and thus will allow them adequate time to react. Messages should be designed taking into account the following factors:

- No more than two displays should be used within any message cycle.

- Each display should convey a single thought.

- Messages should be as brief as possible.

- When abbreviations are used, they should be easily understood.

- The entire message cycle should be readable at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

- Messages shall not scroll horizontally or vertically across the face of the sign.

6F-3. ARROW DISPLAYS

An arrow display is a sign with a matrix of elements. The matrix, capable of either flashing or sequential displays, is intended to provide additional warning and directional information to assist in merging and controlling traffic through or around a temporary traffic control zone. An arrow display should be used in combination with appropriate signs, barricades, or other traffic control devices.

a. Arrow Display Specifications

Arrow displays shall meet the size and other specifications of figure VI-9. A PCMS may be used to simulate an arrow display.

Type A arrow displays are appropriate for use on low-speed urban streets. Type B are appropriate for intermediate-speed facilities and for maintenance or mobile operations on high-speed roadways. Type C arrow displays are intended to be used on high-speed, high-volume traffic control projects.

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An arrow display shall be rectangular, of solid appearance, and finished in nonreflective black. The panel shall be mounted on a vehicle, a trailer, or other suitable support. A vehicle-mounted panel should be provided with remote controls. Minimum mounting height should be 7 feet from the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practicable.

An arrow display shall have the following mode selections:

- A flashing arrow, sequential arrow, or sequential Chevron mode
- Flashing Double Arrow mode
- Flashing Caution mode

Arrow display elements shall be capable of a minimum 50 percent dimming from their full-rated lamp voltage. Full lamp voltage should be used for day, and dimmed mode shall be used for night.

The arrow display shall have suitable elements capable of the various operating modes. If an arrow panel consisting of a bulb matrix is used, the elements should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The color presented by the elements shall be yellow.

Minimum element "on time" shall be 50 percent for the flashing mode and equal intervals of 25 percent for each sequential phase. The flashing rate shall be no fewer than 25 nor more than 40 flashes per minute.

b. Arrow Display Application

An arrow display in the arrow or chevron mode may be used for stationary or moving lane closures. An arrow display in the caution mode shall be used only for shoulder work, blocking the shoulder, or roadside work near the shoulder.

For a stationary lane closing, the arrow display should be located on the shoulder at the beginning of the taper.

Where the shoulder is narrow, the arrow display should be located in the closed lane. If arrow displays are used when multiple lanes are closed in tandem, the preferred position for additional arrow displays is in the closed lane at the start of the merge taper. Under various situations, such as

Operating Mode	Panel Display*
I. At least one of the three following modes shall be provided:	(Right shown; left similar)
Flashing Arrow	Move/Merge Right
Sequential Arrow	Move/Merge Right
Sequential Chevron	Move/Merge Right
II. The following mode shall be provided: Flashing Double Arrow	Move/Merge Right or Left
III. The following mode shall be provided: Flashing Caution	Caution

*Element layout for Type C panel shown

Panel Type	Minimum Size (inches)	Minimum Legibility Distance (miles)	Minimum Number of Elements
A	48 x 24	1/2	12
B	60 x 30	3/4	13
C	96 x 48	1	15

Figure VI-9. Advance Warning Arrow Display Specifications.

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for narrow shoulders, placement may be in the middle or at the end of the merge taper but always behind the channelizers. The panel shall be located behind any channelizing devices used to transition traffic from the closed lane.

For mobile operations where a lane is closed, the arrow display should be located to provide adequate separation from the work operation to allow for appropriate reaction by approaching drivers. A vehicle displaying an arrow display shall be equipped with appropriate signing and/or lighting.

An arrow display shall not be used on a two-lane, two-way roadway for temporary one-lane operation.

An arrow display shall not be used on a multilane roadway to laterally shift all lanes of traffic, because unnecessary lane changing may result.

6F-4. HIGH-LEVEL WARNING DEVICES

The high-level warning device (flag tree) may supplement other traffic control devices in temporary traffic control zones. It is designed to be seen over the top of vehicles. A typical high-level warning device is shown in figure VI-6.

A high-level warning device shall consist of a minimum of two flags with or without a Type B, high-intensity, flashing warning light. The distance from the roadway to the bottom of the lens of the light and to the lowest point of the flag material shall be no less than 8 feet. The flags shall be 16 inches square or larger and shall be orange or fluorescent versions of orange in color. An appropriate warning sign may be mounted below the flags.

High-level warning devices are most commonly used in urban high-density traffic situations to warn motorists of short-term operations.

6F-5. CHANNELIZING DEVICES

a. General

The function of channelizing devices is to warn and alert drivers of conditions created by work activities in or near the traveled way, to protect workers in the temporary traffic control zone, and to guide drivers and pedestrians safely. Channelizing devices include but are not limited to cones, tubular markers, vertical panels, drums, barricades, temporary raised islands, and barriers.

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Devices used for channelization should provide for smooth and gradual traffic movement from one lane to another, onto a bypass or detour, or to reduce the width of the traveled way. They may also be used to separate traffic from the work space, pavement drop-offs, pedestrian paths, or opposing directions of traffic.

Channelizing devices should be constructed and ballasted to perform in a predictable manner when inadvertently struck by a vehicle. If struck, they should yield or break away, and fragments or other debris from the device should not penetrate the passenger compartment of the vehicle or be a potential hazard to workers or pedestrians in the immediate area.

Spacing of channelizing devices should not exceed a distance in feet equal to the speed when used for the taper channelization, and a distance in feet of twice the speed when used for tangent channelization.

Warning lights on channelizing devices. Consideration should be given to fog or snow areas, severe roadway curvature, and usually cluttered environments. Flashing warning lights may be placed on channelizing devices used singly or in groups to mark a spot condition. Warning lights on channelizing devices used in a series shall be steady-burn.

The retroreflective material used on channelizing devices shall have a smooth, sealed outer surface.

Channelizing devices are elements in a total system of traffic control devices for use in temporary traffic control zones. These elements shall be preceded by a subsystem of warning devices that are adequate in size, number, and placement for the type of highway on which the work is to take place. Standard designs of channelizing devices are shown in figure VI-10.

The name and telephone number of the agency, contractor, or supplier may be shown on the non-retroreflective surface of all channelizing devices. The letters and numbers shall be a non-retroreflective color and not over 2 inches in height.

Particular attention should be given to assuring that channelizing devices are maintained and kept clean, visible, and properly positioned at all times. Devices shall be replaced that are damaged and have lost a significant amount of their retroreflectivity and effectiveness.

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b. Cones

(1) Cone Design

Cones shall be predominantly orange, fluorescent red-orange, or fluorescent yellow-orange, not less than 18 inches in height, and shall be made of a material that can be struck without damaging vehicles on impact. Cones shall be a minimum of 28 inches in height when they are used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed.

For nighttime use, cones shall be retroreflective or equipped with lighting devices for maximum visibility. Retroreflection of 28-inch or larger cones shall be provided by a white band 6 inches wide, no more than 3 to 4 inches from the top of the cone, and an additional 4-inch-wide white band a minimum of 2 inches below the 6-inch band.

(2) Cone Application

Traffic cones are used to channelize traffic, divide opposing traffic lanes, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate short-duration maintenance and utility work.

Steps should be taken to ensure that cones will not be blown over or displaced by wind or moving traffic. Cones can be doubled up to increase their weight. Some cones are constructed with bases that can be filled with ballast. Others have special weighted bases, or weights such as sandbag rings that can be dropped over the cones and onto the base to provide added stability. Ballast, however, should not present a hazard if the cones are inadvertently struck.

c. Tubular Markers

(1) Design

Tubular markers shall be predominantly orange, not less than 18 inches high, minimum 2 inches wide when facing traffic, and made of a material that can be struck without damaging impacting vehicles. Tubular markers shall be a minimum of 28 inches high when used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed.

For nighttime use, tubular markers shall be retroreflective. Retroreflection of tubular markers shall be provided by two 3-inch-wide white bands placed a maximum of 2 inches from the top, with a maximum of 6 inches between the bands.

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(2) Application

Tubular markers have less visible area than other devices and should be used only where space restrictions do not allow for the use of other more visible devices. They may be used effectively to divide opposing lanes of traffic, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate edge of pavement dropoff where space limitations do not allow the use of larger devices.

Steps should be taken to assure that tubular markers will not be blown over or displaced by traffic by either affixing them to the pavement with anchor bolts or adhesive, using weighted bases, or weights that can be dropped over the tubular markers and onto the base to provide added stability. Ballast, however, should not be allowed to present a hazard if the tubular markers are inadvertently struck. If a noncylindrical device is used, and it could be displayed with a width less than the minimum facing traffic, it shall be attached to the pavement to ensure that the width facing traffic meets the minimum requirements.

d. Vertical Panels

(1) Design

Vertical panels shall be 8 to 12 inches wide and at least 24 inches high. They shall have orange (fluorescent red-orange or fluorescent yellow-orange) and white stripes, and be retroreflectorive. Panel stripe widths shall be 6 inches, except where panel heights are less than 36 inches, when 4-inch stripes may be used. If used for two-way traffic, back-to-back panels shall be used.

Markings for vertical panels shall be alternating orange and white retroreflectorized stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). Vertical panels used on expressways, freeways, and other high-speed roadways shall have a minimum of 270 square inches of retroreflective area facing traffic.

(2) Application

Vertical panels may be used to channel traffic, divide opposing lanes of traffic, divide traffic lanes or in place of barricades where space is limited.

e. Drums

(1) Design

Drums used for traffic warning or channelization shall be constructed of lightweight, flexible, and deformable materials

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and be a minimum of 36 inches in height; and have at least an 18-inch minimum width, regardless of orientation. Steel drums shall not be used. The markings on drums shall be horizontal, circumferential, alternating orange and white retroreflective stripes 4 to 6 inches wide. Each drum shall have a minimum of two orange and two white stripes. Any non-retroreflective spaces between the horizontal orange and white stripes, shall not exceed 2 inches wide. Drums shall have closed tops that will not allow collection of roadwork or other debris.

(2) Application

Drums are most commonly used to channelize or delineate traffic flow but may also be used singly or in groups to mark specific locations. Drums are highly visible and have good target value, given the appearance of being formidable obstacles and, therefore, command the respect of drivers. They are portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but are generally used in situations where they will remain in place for a prolonged period.

Drums should not be weighted with sand, water, or any material to an extent that would make them hazardous to motorists, pedestrians, or workers. When they are used in regions susceptible to freezing, they should have drainage holes in the bottom so water will not accumulate and freeze, causing a hazard if struck by a motorist. Ballast shall not be placed on top of the drum.

f. Barricades

(1) Design

A barricade is a portable or fixed device having from one to three rails with appropriate markings. It is used to control traffic by closing, restricting, or delineating all or a portion of the right-of-way.

Barricades shall be of three types: Type I, Type II, or Type III.

Stripes on barricade rails shall be alternating orange and white retroreflective stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). The stripes shall be 6 inches wide, except where rail lengths are less than 36 inches, when 4-inch-wide stripes may be used. The minimum rail length is 24 inches. Barricades used on expressways, freeways, and other high-speed roadways shall have a minimum of 270 square inches of retroreflective area facing traffic.

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Where a barricade extends entirely across a roadway, the stripes should slope downward in the direction toward which traffic must turn. Where both right and left turns are provided, the stripes may slope downward in both directions from the center of the barricade or barricades. Where no turns are intended, the stripes should slope downward toward the center of the barricade or barricades.

Barricade rails should be supported in a manner that will allow them to be seen by the motorist and provide a stable support not easily blown over by the wind or traffic. For Type I barricades, the support may include other unstriped horizontal panels necessary to provide stability.

Barricades are located adjacent to traffic and are therefore subject to impact by errant vehicles. Because of their vulnerable position and the hazard they could create, they should be constructed of lightweight materials and have no rigid stay bracing for A-frame designs.

On high-speed expressways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

(2) Application

Type I or Type II barricades are intended for use in situations where traffic is maintained through the temporary traffic control zone. They may be used singly or in groups to mark a specific condition, or they may be used in a series for channelizing traffic. Type I barricades normally would be used on conventional roads or urban streets and arterials. Type II barricades have more retroreflective area and are intended for use on expressways and freeways or other high-speed roadways.

Type III barricades used at a road closure may extend completely across a roadway or from curb to curb. Where provision is made for access of authorized equipment and vehicles, the responsibility for the Type III barricades should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic, the Type III barricade should not be extended completely across a roadway. A sign with the appropriate legend concerning permissible use by local traffic shall be mounted. (See section 6F-1.a.5.)

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Signs may be erected on barricades, particularly those of the fixed type, that offer a most advantageous facility for this purpose. The ROAD CLOSED and DETOUR ARROW signs, and the LARGE ARROW warning signs, for example, can be mounted effectively on or above the barricade that closes the roadway.

g. Portable Barriers

The need for portable barriers should be determined by engineering analysis and the protective requirements of the location, not the channelizing needs. They should be designed according to chapter 9 of the AASHTO Roadside Design Guide.[10]

When serving the additional function of channelizing traffic, the barrier taper shall meet standard channelizing taper lengths. The channelizing barrier shall be supplemented by standard delineators, channelizing devices, or pavement markings. Channelizing barriers should not be used for a merging taper except in low-speed urban areas.

h. Temporary Raised Islands

The temporary raised island should only be used on roadways with speeds of 45 mph or less except when recommended by an engineering study.

Temporary raised islands, not to exceed 4 inches in height, may be used to supplement channelizing devices and pavement markings to separate traffic flows in two-lane, two-way operations (TLTWO). Pavement edge lines may be placed on the island itself. Islands may also have application in other than TLTWO where physical separation of traffic from the temporary traffic control zone is not required.

One type of temporary raised island is 4 inches high by 18 inches wide and has rounded or chamfered corners. They may be constructed of Portland cement concrete or bituminous concrete. They should be designed according to chapter 9 of the AASHTO Roadside Design Guide.[11]

i. Other Channelizing Devices

Channelizing devices, other than those specified above, may be required for special situations based on an engineering study. Such devices should conform to the general size, color, stripe

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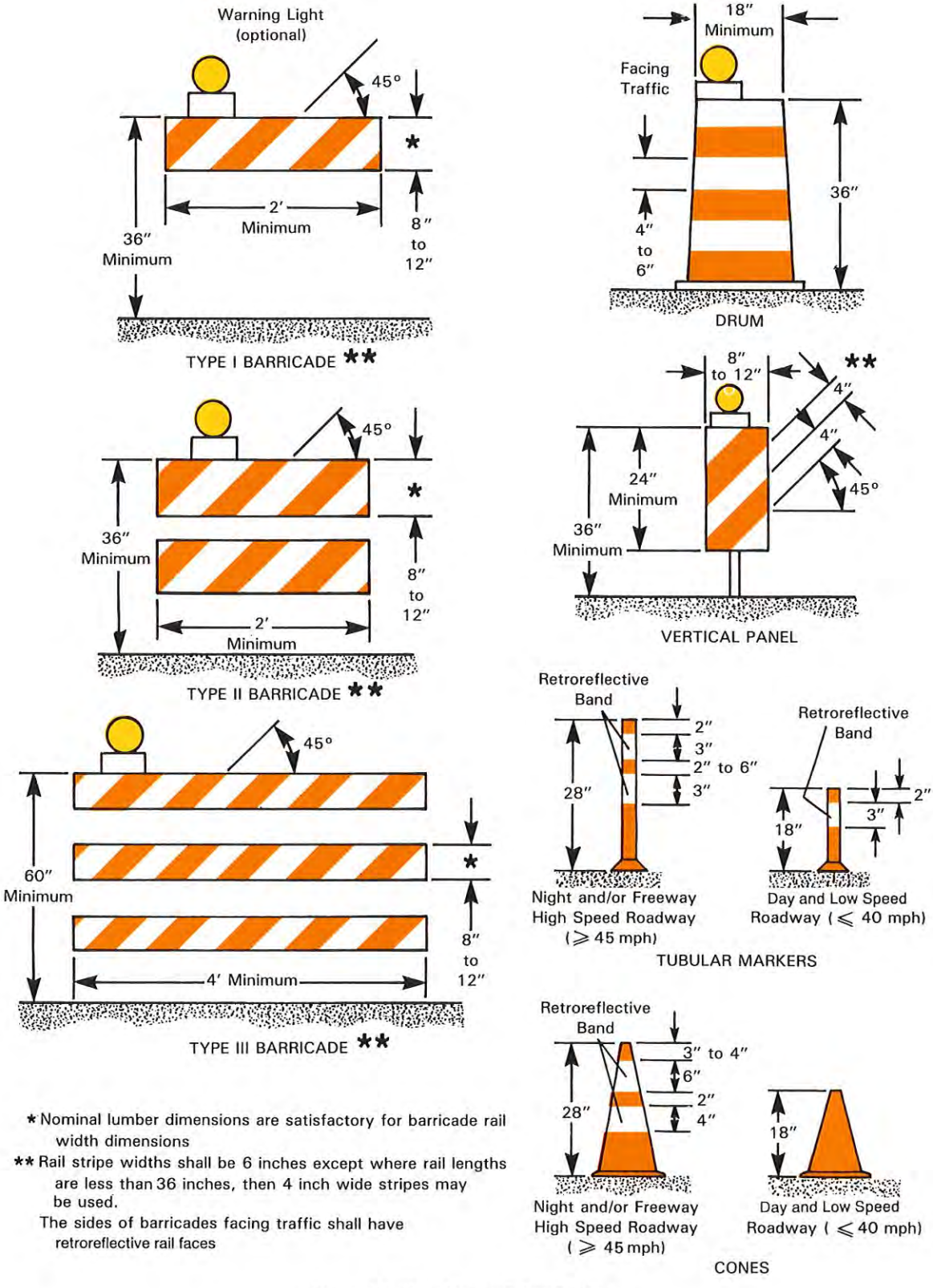

* Nominal lumber dimensions are satisfactory for barricade rail width dimensions

** Rail stripe widths shall be 6 inches except where rail lengths are less than 36 inches, then 4 inch wide stripes may be used.

The sides of barricades facing traffic shall have retroreflective rail faces

Figure VI-10. Channelizing Devices.

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pattern, retroreflection, and placement characteristics established for standard devices.

6F-6. MARKINGS

a. Pavement Marking Applications

Adequate pavement markings shall be maintained along paved streets and highways in temporary traffic control zones. Obliterated markings shall be unidentifiable as pavement markings under day or night, wet or dry conditions. The work should be planned and staged to provide the best possible conditions for the placement and removal of the pavement markings.

It is intended, to the extent possible, that motorists be provided markings within a work area comparable to the markings normally maintained along adjacent roadways, particularly at either end of the work area. The following guidelines set forth the level of markings and delineation for various work area situations.

(1) All markings shall be in accordance with part III A and part III B, except as indicated under 6F-6b (Interim Markings) of this manual.

(2) Markings shall be maintained in long-term stationary work areas and shall match and meet the markings in place at both ends of the work area.

(3) Markings shall be placed, along the entire length of any surfaced detour or temporary roadway, such detour or roadway is opened to traffic.

(4) Centerline/lane lines should be placed, replaced, or delineated where appropriate before the roadway is opened to traffic.

(5) Markings should be provided in intermediate-term stationary work areas, to the extent practicable.

(6) In any work area where it is not practical to provide a clear path by markings, appropriate warning signs, channelizing devices, and delineation shall be used to indicate the required vehicle paths.

All markings and devices used to delineate vehicle and pedestrian paths shall be carefully reviewed during daytime and nighttime periods to avoid inadvertently leading drivers or pedestrians from the intended path.

Proper pavement marking obliteration leaves a minimum of pavement scars and completely removes old marking materials.

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Obliterated markings shall be unidentifiable as pavement markings under day or night, wet or dry conditions. Overlaying existing stripes with black paint or asphalt does not meet the requirements of covering, removal, or obliteration; however, the use of removable, nonreflective, preformed tape is permitted where markings need to be covered temporarily.

b. Interim Markings

Interim pavement markings are those that may be used until it is practical and possible to install pavement markings that meet the full MUTCD standards for pavement markings. Normally, it should not be necessary to leave interim pavement markings in place for more than 2 weeks. All interim pavement markings, including pavement markings for no-passing zones, shall conform to the requirements of sections 3A and 3B with the following exceptions:

(1) All interim broken-line pavement markings shall use the same cycle length as permanent markings and be at least 4 feet long, except that half-cycle lengths with a minimum of 2-foot stripes may be used for roadways with severe curvature. (See section 3A-6.) This applies to white lane lines for traffic moving in the same direction and yellow center lines for two-lane roadways when it is safe to pass.

(2) For those interim situations of 3 calendar days or less for a two- or three-lane road, no-passing zones may be identified by using signs rather than pavement markings. (See sections 3B-4, 3B-5, and 3B-6.) Also, signs may be used in lieu of pavement markings on low-volume roads for longer periods, when this practice is in keeping with the State's or highway agency's policy. These signs should be placed in accordance with sections 2B-21, 2B-22, and 2C-38.

(3) The interim use of edgelines, channelizing lines, lane reduction transitions, gore markings and other longitudinal markings, and the various non-longitudinal markings (stop line, railroad crossings, crosswalks, words, symbols, etc.) should be in keeping with the state's or highway agency's policy.

c. Raised Pavement Markers

Raised/recessed pavement markers should be considered for use along surfaced detour or temporary roadways, and other changed or new travel lane alignments, because of the need to accentuate changed travel paths and their wet-weather performance capabilities.

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Retroreflective raised/recessed pavement markers, or non-retroreflective raised/recessed pavement markers supplemented by retroreflective markers, may be substituted for, or used as a supplement to markings prescribed in sections 3A and 3B and subsection b, above.

d. Delineators

Delineators may be used in work areas to indicate the alignment of the roadway and to outline the required vehicle path through the temporary traffic control zone. Delineators, when used, shall be used in combination with, or be supplemental to, other traffic control devices.

When used, delineators shall be mounted on suitable supports so that the reflecting unit is about 4 feet above the near roadway edge. The standard color for delineators used along both sides of two-way streets and highways and the right side of one-way roadways shall be white. Delineators used along the left side of one-way roadways shall be yellow. Spacing along roadway curves should be as set forth in section 3D-5, and should be spaced so that several delineators are always visible to the driver.

6F-7. LIGHTING DEVICES

a. Function

Temporary traffic control activities often create conditions on or near the traveled way that are particularly unexpected at night, when drivers' visibility is sharply reduced. It is often desirable and necessary to supplement retroreflectorized signs, barriers, and channelizing devices with lighting devices.

Four types of lighting devices are commonly used: floodlights, hazard identification beacons, steady-burning electric lamps, and warning lights.

In work areas where a study indicates a nighttime accident problem can be corrected with area illumination, consideration may be given to providing roadway lighting.

b. Floodlights

On temporary traffic control projects, floodlights have a limited but important application. Temporary traffic control activities on urban freeways must frequently be conducted during nighttime periods when traffic volumes are lower. Sometimes, large temporary traffic control contracts are also operated on double shift, requiring night work. When nighttime work is required for these or similar types of projects, floodlights should be used to illuminate flagger stations, equipment

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crossings, and other areas where existing light is not adequate for the work to be performed safely.

In no case shall floodlighting be permitted to create a disabling glare for drivers. The adequacy of the floodlight placement and elimination of potential glare can best be determined by driving through and observing the floodlighted area from each direction on the main roadway after initial floodlight setup.

Maintenance activities on urban freeways with high-volume, high-density traffic conditions are frequently conducted during nighttime periods (with low traffic volumes). Good floodlighting of the work site is needed because the workers need to see what they are doing, and because the workers and the work space be protected from, and seen by, passing drivers.

c. Flashing Identification Beacons (Flashing Electric Lights)

A flashing identification beacon is a flashing yellow light (minimum diameter, 8 inches) used at points of special to alert drivers' attention to these conditions. When used, the flashing beacon should operate 24 hours a day.

On temporary traffic control projects, because of the time and effort required to install these units and put them into operation, they are generally used at locations where frequent changes would not be required.

On projects where an existing dual highway is being upgraded to freeway standards (which requires the use of crossovers to permit stage construction), flashing beacons have been used effectively to call drivers' attention to the condition created by the channelizing devices. Similarly, the temporary terminus of a freeway (where all traffic is channelized into an exit) is a location where beacons have alerted drivers of the speed reduction necessary in transitioning from freeway to local road operations.

Flashing identification beacons may be used singly or in groups containing more than one unit.

During normal daytime maintenance operations, the functions of flashing beacons are adequately provided by rotating dome or strobe lights on maintenance vehicles. However, flashing beacons may be installed at locations where maintenance activity requires an obstruction to remain in the roadway at night. (See section 4E-5.)

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d. Steady-Burning Electric Lamps

As used herein, steady-burning electric lamps shall mean a series of low-wattage yellow electric lamps. They may be used to mark obstructions, but they are generally less effective than flashing lights for such use, because of their attention-getting effect. However, lights are needed to delineate the traveled way through and around obstructions in a temporary traffic control zone, the delineation shall be accomplished by steady-burning lamps.

Steady-burning lamps, placed in a line on appropriate channelizing devices, are effective in delineating the proper vehicle path through temporary traffic control zones that require changing patterns of traffic movement. Steady-burning lamps are also used on detours, on lane closures, when the roadway alignment changes in tapers, and other situations where the headlights do not provide retroreflection to delineate the intended vehicle path.

The application of these devices during maintenance work is infrequent due to the generally short-term nature of the work. A type of maintenance activity where steady-burning lamps could be used is removal and replacement of a part of a bridge deck. The lamps could be mounted on barricades and help channel traffic around the work space.

e. Warning Lights

The light weight and portability of warning lights are advantages that make these devices useful as supplements to the retroreflectorization on hazard warning devices. The flashing lights are effective in attracting a driver's attention and, therefore, provide an excellent means of identifying the hazard.

As used herein, warning lights are portable, lens-directed, enclosed lights. The color of the light emitted shall be yellow. They may be used in either a steady-burn or flashing mode. Warning lights shall be in accordance with the current ITE Purchase Specification for Flashing and Steady-Burn Warning Lights.[12]

Warning lights shall have a minimum mounting height of 30 inches to the bottom of the lens. Type A low-intensity flashing warning lights are most commonly mounted on barricades, drums,

[12]Included in the Equipment and Material Standards of the Institute of Transportation Engineers Publication No. ST 017; 525 School Street, S.W., Suite 410, Washington, D.C. 20024. Telephone: 202-554-8050.

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vertical panels, or advance warning signs, and are intended to warn drivers that they are approaching or in a hazardous area.

Type B high-intensity flashing warning lights are normally mounted on advance warning signs or on independent supports. Extremely hazardous site conditions within temporary traffic control zones may require that the lights be effective in daylight as well as dark. They are designed to operate 24 hours per day. Flashers shall not be used for delineation, as they would tend to obscure the desired vehicle path.

Type C steady-burn lights are intended to be used to delineate the edge of the traveled way on detour curves, on lane changes, on lane closures, and on other similar conditions.

Type A low intensity flashing warning lights and Type C steady-burn warning lights shall be maintained so as to be visible on a clear night from a distance of 3,000 feet. Type B high intensity flashing warning lights shall be maintained so as to be visible on a sunny day, when viewed without the sun directly on or behind the device from a distance of 1,000 feet.

6F-8. OTHER DEVICES

a. Impact Attenuators

Impact attenuators are systems that mitigate the effects of errant vehicles that strike hazards, either by smoothly decelerating the vehicle to a stop when hit head-on, or by redirecting the errant vehicle. Impact attenuators in temporary traffic control zones protect the motorists from the exposed ends of barriers, fixed objects, and other hazards. Two types of impact attenuators used in temporary traffic control zones are roadside attenuators and truck-mounted attenuators (TMA's). Specific information on the use of impact attenuators can be found in the AASHTO Roadside Design Guide, Chapter 9.[13]

Attenuators must pass acceptable performance testing and be designed for each application to ensure performance that will safely stop or redirect errant vehicles. Periodic inspection of these devices is necessary to assure that attenuators function as intended throughout their useful life or that they undergo prompt repair/replacement if hit or damaged.

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(1) Roadside Attenuators

Roadside attenuators are used in the same manner as permanent highway installations to protect motorists from the exposed ends of barriers, fixed objects, and other hazards. Two types of stationary attenuators are commonly used and must be designed for the specific application intended as follows:

(a) Redirective Type

The redirective type is an assembled unit designed to absorb head-on vehicle impacts and telescope toward the rear; also it may be capable of absorbing side impacts by redirecting a vehicle.

Redirective attenuators normally are used when the exposed object is narrow, or when space for a nonredirective type is unavailable, such as on surface streets near adjacent intersecting roadways. The attenuator width must be wider than the hazard object, but as close to the object width as possible, to prevent its lateral intrusion into the traffic lanes.

(b) Nonredirective Type

The nonredirective type may be struck head-on, and may be the sand-filled plastic barrel system or other acceptable energy-absorbing device designed to stop errant vehicles safely.

Nonredirective impact attenuators must be checked frequently for vehicle impacts because, once hit, they may not function as designed for a second hit. When sand-filled barrels are fractured, the sand is scattered, site cleanup is needed, and the attenuator must be restored with replacement barrels and sand.

(2) Truck-Mounted Attenuators

Trucks or trailers are often used as protective vehicles to protect workers or work equipment from errant vehicles. These protective vehicles are normally equipped with flashing arrows, changeable message signs, and/or flashers, and must be located properly in advance of the workers and/or equipment they are protecting. However, these protective vehicles may themselves cause injuries to occupants of the errant vehicles if they are not equipped with truck-mounted attenuators (TMA's).

TMA's capable of absorbing the impact of errant vehicles can be attached to the rear of these protective vehicles to

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reduce, the severity of rear-end crashes. There are a variety of TMA designs available.

The protective truck must be positioned a sufficient distance in front of the workers or equipment being protected to allow for appropriate vehicle roll-ahead, but not so far that errant vehicles will travel around the vehicle and strike the workers/equipment. The attenuator should be in the full down-and-locked position. For stationary operations, the truck's parking brake should be set and, when possible, the front wheels turned away from the work site.

b. Portable Barriers

Portable barriers are designed to prevent vehicles from penetrating work areas behind the barrier while minimizing occupant injuries. They may also be used to separate two-way traffic. These devices may be constructed of concrete, metal, or any material that can physically prevent vehicular penetration.

Portable barriers may serve to channelize traffic. Use for a specific project should be determined by engineering analysis. However, the protective requirements of the work area, not the channelizing needs, govern the use of portable barriers. When serving the additional function of channelizing traffic, portable barriers should be of a light color for increased visibility. For nighttime visibility, barriers shall be supplemented with standard delineation, markings, or channelizing devices. More specific information on the use of portable barriers and impact attenuators can be obtained from chapters 8 and 9 respectively, of the AASHTO Roadside Design Guide.[14]

Warning lights may be mounted on continuous barriers. On each side of the roadway only the first two yellow warning lights at the start of a continuous barrier should be Type B flashing. Subsequent warning lights on the barrier shall be Type C yellow, steady-burning for channelization.

The effect of striking the ends of barriers should be mitigated by use of impact attenuators or by flaring the ends of barriers away from the traveled way.

c. Temporary Traffic Signals

Temporary traffic signals can be used for special applications to control traffic flow at temporary traffic control zones. These applications include a highway intersection with a temporary haul

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road or equipment crossing, and temporary traffic control zones with alternate one-way traffic flow, such as bridge construction.

All traffic signal and control equipment shall meet the standards and specifications prescribed in part IV of this manual.

One-way traffic flow requires an all-red interval of sufficient duration for traffic to clear the portion of the temporary traffic control zone controlled by the traffic signals. To avoid the display of conflicting signals at each end of the temporary traffic control zone, traffic signals shall be either hard-wired or controlled by radio signals.

d. Rumble Strips

Rumble strips are transverse strips of rough-textured surface used to supplement standard or conventional traffic control devices. Rumble strips may be used to alert drivers of unusual or unexpected traffic conditions or geometrics, or to bring the driver's attention to other warning devices. They provide a vibratory and audible warning that supplements visual stimuli.

A rumble strip may consist of raised strips or depressed grooves. The cross-section may be rectangular, domed, or trapezoidal in shape. The strips or grooves should be placed transverse to the direction of traffic. The intervals between rumble strip pads should be reduced as the distance to the hazard diminishes, to create a sensation of acceleration for motorists.

The first rumble strip pad should be placed before the advance warning devices. The last rumble strip pad should be placed a minimum of 250 feet in advance of the traffic condition, gore, work space, or stop position. Rumble strip pads should not be placed on short horizontal or vertical curves where loss of vehicle control may occur because of the action of the rumble strips on a vehicle's suspension system. Rumble strips may be portable devices.

A sign warning drivers of the presence of rumble strips may be placed in advance of the strips.

e. Screens

Screening is used to block the driver's view of activities that can distract from the driving task. Screening also contains the work area and keeps dust and debris off the pavement. Screens are primarily useful on long-term temporary traffic control projects.

Screens may improve safety and traffic flow where traffic volumes approach the roadway capacity because they discourage "gawking" and reduce headlight glare from oncoming traffic.

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Screens may be mounted on the top of portable concrete barriers that separate two-way traffic. Screens should not be mounted where they could restrict driver visibility and sight distance. Additional information regarding screens can be obtained from chapter 9 of the AASHTO Roadside Design Guide.[15]

f. Opposing Traffic Lane Divider

Opposing traffic lane dividers are delineation devices used as center lane dividers to separate opposing traffic on a two-lane, two-way operation. The upright, orange-colored panel shall be approximately 12 inches wide by 18 inches high. The legend on the divider shall be two opposing arrows, similar to those in the legend on the TWO-WAY TRAFFIC sign (W6-3). The divider should be made of lightweight material.

6G. TYPES OF TEMPORARY TRAFFIC CONTROL ZONE ACTIVITIES

Each traffic control zone is different. Many variables, such as location of work, road type, speed, volume, geometrics, vertical and horizontal alignment, pedestrians, and intersections affect the needs of each zone. The goal of traffic control in work areas is safety with minimum disruption to traffic, and the key factor in making the temporary traffic control zone safe and efficient is proper judgment.

Bicyclists also need protection and access to the roadway. If a bicycle path is closed because of work in progress, a signed alternate route should be provided. Bicyclists should not be directed onto the same path used by pedestrians. For more details on controlling bicycle traffic, see part IX of the MUTCD.

Utility work takes place both within the roadway and outside the shoulder, to construct and maintain the hardware and equipment used to provide power, light, water, gas, and telephone service. Utility operations are generally short daytime operations, except under emergency conditions. Often they are performed on low-volume, low-speed streets. Operations often involve intersections, as that is where many of the network junctions occur. The crew size is usually small, only a few vehicles are involved, and the number and types of traffic control devices placed in the temporary traffic control zone may be minimal. As discussed in section 6G-20a.(4), however, the reduced number of devices in this situation should be offset by the use of high-visibility devices, such as special lighting units on work vehicles. Figures TA-6, TA-10, TA-15, TA-18, TA-21, TA-22, TA-23, TA-26 and TA-33 are examples of typical applications for utility operations. Other typicals may apply as well.

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In this section, typical temporary traffic control zone situations are organized according to duration and location of work and highway type. Section 6H, which follows the same organization, presents layouts of these typical temporary traffic control zone situations. Table VI-4 in section 6H indexes by figure number the typical temporary traffic control zone applications described in this section.

6G-1. TYPICAL APPLICATIONS

Typical applications include a variety of traffic control methods, but do not include a layout for every conceivable work situation. Typical applications should be altered, when necessary, to fit the conditions of a particular temporary traffic control zone. Standards presented in sections 6A-6F should be given priority over the examples given in the typical applications.

The typical applications illustrated in section 6H generally represent highway agency norms. Other devices may be added to supplement the devices shown in the typical applications, and sign spacings and taper lengths may be increased to provide additional time or space for driver response. In some situations, however, such as an urban setting, too many devices can spread signing over too long a distance to be meaningful. When conditions are not as difficult as those depicted in the typical application, fewer devices may suffice.

Although portable barriers are frequently indicated in the typical applications of section 6H, they are not traffic control devices in themselves. However, when placed in a position identical to a line of channelizing devices and marked and/or equipped with appropriate channelizing features to give guidance and warning both day and night, they serve as traffic control devices and, therefore, must conform to all requirements for such devices set forth throughout part VI.

6G-2. SELECTING THE TYPICAL APPLICATION

Selecting the most appropriate typical application and modifications for a temporary traffic control zone requires knowledge and understanding of that zone. Although there are many ways of categorizing temporary traffic control zone applications, the three factors mentioned earlier (work duration, work location, and highway type) have been used to characterize the typicals illustrated in section 6H.

a. Duration of Work

Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. The five

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categories of work duration and their time at a location are as follows:

- Long-term stationary—Work that occupies a location more than 3 days.
- Intermediate-term stationary—Work that occupies a location from overnight to 3 days.
- Short-term stationary—daytime work that occupies a location from 1 to 12 hours.
- Short, Duration—Work that occupies a location up to 1 hour.
- Mobile—Work that moves intermittently or continuously.

(1) Long-Term Stationary

At long-term stationary temporary traffic control zones, there is ample time to install and realize benefits from the full range of traffic control procedures and devices that are available for use. Generally, larger channelizing devices are used, as they have more retroreflective material and offer better nighttime visibility. The larger devices are also less likely to be displaced or tipped over—an important consideration during those periods when the work crew is not present. Furthermore, as long-term operations extend into nighttime, retroreflective and/or illuminated devices are required. Temporary roadways and barriers can be provided, and inappropriate markings should be removed and replaced with temporary markings.

(2) Intermediate-Term Stationary

During intermediate-term stationary work, it may not be feasible or practical to use procedures or devices that would be desirable for long-term stationary temporary traffic control zones, such as altered pavement markings, barriers, and temporary roadways. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time. In other instances, there might be insufficient payback time to make more elaborate traffic control economically attractive.

(3) Short-Term Stationary

Most maintenance and utility operations are short-term stationary work. The work crew is present to maintain and monitor the temporary traffic control zone. The use of flagger is an option. Lighting and/or retroreflective devices should be chosen

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to accommodate varying seasonal, climatic, and visibility situations.

(4) Short Duration

During short-duration work, there are hazards involved for the crew in setting up and taking down the traffic controls. Also, since the work time is short, the time during which motorists are affected is significantly increased as the traffic control is expanded. Considering these factors, it is generally held that simplified control procedures may be warranted for short-duration work. Such shortcomings may be offset by the use of other, more dominant devices such as special lighting units on work vehicles.

(5) Mobile

Mobile operations are work activities that move along the road either intermittently or continuously. Mobile operations often involve frequent short stops, each as much as 15 minutes long, for activities such as litter cleanup, pothole patching, or utility operations and are similar to stationary operations. Warning signs, flashing vehicle lights, flags, and/or channelizing devices should be used.

Mobile operations also include work activities in which workers and equipment move along the road without stopping, usually at slow speeds. The advance warning area moves with the work area. Traffic should be directed to pass safely. Parking may be prohibited, and work should be scheduled during off-peak hours. For some continuously moving operations—such as street sweeping — where volumes are light and visibility is good, a well-marked and well-signed vehicle may suffice. If volumes and/or speeds are higher, a shadow or backup vehicle equipped as a sign truck, preferably supplied with a flashing arrow display, should follow the work vehicle. Where feasible, warning signs should be placed along the roadway and moved periodically as the work progresses. In addition, vehicles may be equipped with such devices as flags, flashing vehicle lights, truck-mounted attenuators, and appropriate signs. These devices may be required individually or in various combinations, including all of them, including all of them, as determined necessary.

Safety should not be compromised by using fewer devices simply because the operation will frequently change its location. Portable devices should be used. Flaggers may be used, but caution must be exercised so they are not exposed to unnecessary hazards. The control devices should be moved periodically to keep them near the work area. If mobile operations are in effect on a high-speed travel lane of a multilane divided highway, flashing arrow displays should be used.

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b. Location of Work

The choice of traffic control needed for a temporary traffic control zone depends upon where the work is located. As a general rule, the closer the work is to traffic, the more control devices are needed.

Work can take place in the following locations:

(1) **Outside of the shoulder edge.** Devices may not be needed if work is confined to an area 15 or more feet from the edge of the shoulder. Consideration should be given to roadway characteristics, roadway geometrics, and vehicle speed. A general warning sign like ROAD MACHINERY AHEAD should be used if workers and equipment must occasionally move closer to the highway.

(2) **On or near the shoulder edge.** The shoulder should be signed as if work were on the road itself, since it is part of the drivers' "recovery area." Advance warning signs are needed. Channelizing devices are used to close the shoulder, direct traffic, and keep the work space visible to the motorist. Portable barriers may be needed to prevent encroachment of errant vehicles into the work space and to protect workers.

(3) **On the median of a divided highway.** Work in the median may require traffic control for both directions of traffic, through the use of advance warning signs and channelization devices. If the median is narrow, with a significant chance for vehicle intrusion into long-term work sites and/or crossover accidents, portable barriers should be used.

(4) **On the traveled way.** Work on the traveled way demands optimum protection for workers and maximum advance warning for drivers. Advance warning must provide a general message that work is taking place, information about specific hazards, and actions the driver must take to drive through the temporary traffic control zone.

c. Roadway Type

Roadway type is also a primary factor in the use of temporary traffic control zone traffic control devices. Typical application diagrams of the following categories of roadway type are included in section 6H:

(1) Rural Two-lane Roadways
(2) Urban Arterial Roads
(3) Other Urban Streets
(4) Rural or Urban Multilane Divided and Undivided Highways
(5) Intersections
(6) Freeways

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Rural two-lane roadways are characterized by relatively low volumes and high speeds. Urban arterial roads often have lower speeds, but they may require significant controls because of higher traffic volumes and closer spacing of such design features as intersections. Other urban streets with light traffic volumes will generally require fewer but more closely spaced devices. Major arterial and freeways need the highest type of traffic control, primarily because of high speeds and often high volumes of traffic.

To improve safety, typical designs may be modified to a more elaborate treatment, as indicated by the following:

- Additional devices
  - Additional signs
  - Flashing arrow displays
  - More channelizing devices at closer spacing
  - Temporary raised pavement markers
  - High-level warning devices
  - Portable changeable message signs
  - Portable traffic signals
  - Portable barriers
  - Impact attenuators
  - Screens
  - Rumble strips
- Upgrading of devices
  - A full complement of standard pavement markings in areas of high hazard
  - Brighter and/or wider pavement markings
  - Larger signs
  - Higher type channelizing devices
  - Barriers in place of channelizing devices
- Improved geometrics at detours or crossovers, giving particular attention to the provisions set forth in section 6B
- Increased distances
  - Longer advance warning area
  - Longer tapers
- Lighting
  - Temporary roadway lighting
  - Steady-burn lights used with channelizing devices
  - Flashing lights for isolated hazards
  - Illuminated signs
  - Floodlights

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When conditions are not as difficult as those depicted in the typical applications, fewer devices may suffice. However, uniformity of devices and their application is always extremely important.

6G-3. WORK OUTSIDE THE SHOULDER

Traffic control depends primarily on devices such as advance warning signs, flashing vehicle lights, and flags. An advance warning sign should be used when any of the following conditions occur:

- Work will be performed immediately adjacent to the shoulder at certain stages of the activity.
- Equipment may be moved along or across the highway.
- Motorists may be distracted by the work activity.

A typical sign for this situation may be ROAD WORK AHEAD. If the equipment travels on or crosses the roadway, it should be equipped with appropriate flags, flashing lights, and/or a SLOW MOVING VEHICLE symbol.

A typical layout for stationary work outside of the shoulder is shown in figure TA-1. Special signing for a blasting zone is shown in figure TA-2. A typical layout for short-duration, mobile and moving work outside of the shoulder and on the shoulder is shown in figure TA-4.

6G-4. WORK ON THE SHOULDER

This section describes typical applications that cover shoulder work. It is divided into shoulder work that does and does not interfere with traffic.

a. No Encroachment on Traveled Way

There is no direct interference with traffic. When the shoulder is occupied or closed, the drivers should be advised and the workers should be protected. In some instances, this may require the use of portable barriers if work is directly adjacent to the travel lane. Usually, the single warning sign, SHOULDER WORK, is adequate. When an improved shoulder is closed on a high-speed roadway, it should be treated as a closing of a portion of the road system because drivers expect to be able to use it in emergencies. Motorists should be given ample advance warning that shoulders are closed to use as refuge areas throughout a specified length of the approaching temporary traffic control zone. The signs should read SHOULDER CLOSED with distances indicated. The work space on the shoulder should be closed off by a taper of

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channelizing devices with a length of 1/3 L, using the formulas in section 6C-3. Flashing arrow displays should be used only in the caution mode.

b. Minor Encroachment on Traveled Way

When work is on the shoulder or takes up part of a lane, traffic volumes, vehicle mix (buses, trucks, and cars), speed, and capacity should be analyzed to determine whether the affected lane should be closed. The lane encroachment should permit a remaining lane width of 10 feet or the lane should be closed. However, 9 feet is acceptable for short-term use on low-volume, low-speed roadways for traffic that does not include longer and wider heavy commercial vehicles. Figure TA-6 illustrates a method for handling traffic where the stationary or short duration work space encroaches slightly into the traveled way.

6G-5. WORK WITHIN TRAVELED WAY—RURAL TWO-LANE

a. Detours

Typical layouts for detours of two-lane highways are shown in figures TA-7, TA-8, and TA-9. Figure TA-7 illustrates the controls around an area where a section of roadway has been closed and a bypass constructed. Channelizing devices and pavement markings are used to indicate the transition to the temporary roadway.

Detour signing is usually handled by the traffic engineer with authority over the roadway because it is considered a traffic routing problem. Detour signs are used to direct traffic onto another roadway. When the detour is long, signs should be installed to periodically remind and reassure drivers that they are still on a detour. This is done by using the DETOUR MARKER (M4-8) or DETOUR (M4-9) signs.

When an entire roadway is closed, as illustrated in figure TA-8, a detour should be provided and traffic should be warned in advance of the closure. This illustration is an example for a closing 10 miles from the intersection. If local traffic is allowed to use the roadway up to the closure, the ROAD CLOSED TO THRU TRAFFIC sign should be used. The portion of the road open to local traffic should have adequate signing, marking, and protection.

Detours should be signed so that traffic will be able to get through the entire area and back to the original roadway as shown in figure TA-9.

b. One-Way Traffic Control

When one lane is closed on two-lane, two-way roads, the remaining lane must be used by traffic traveling in both

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directions. Techniques for controlling traffic under such conditions are described in section 6C-5.

6G-6. WORK WITHIN TRAVELED WAY—URBAN STREETS OR ARTERIAL

Urban temporary traffic control zones may be divided into segments. Decisions must be reached as to how to control vehicular traffic, how many lanes are required, or whether any turns should be prohibited at intersections. Pedestrian traffic must be considered. If work will be done on the sidewalk, will it be necessary to close the sidewalk and assign the pedestrians to another path? Next, decisions must be reached as to how to maintain access to business, industrial, and residential areas. Even if the road is closed to vehicles, pedestrian access and walkways must be provided.

Bicyclists' protection and access are especially needed on these types of roadways. If a bicycle path is closed because of the work being done, a signed alternate route should be provided. Bicyclists should not be directed onto the path used by pedestrians. For more details on controlling bicycle traffic, see part IX of the MUTCD.

Utility work takes place both within the roadway and outside the shoulder to construct and maintain the hardware and equipment used to provide power, light, water, gas, or telephone service. Utility operations are generally short daytime operations, except under emergency conditions. Often they are performed in low-volume and low-speed streets. Operations often involve intersections, since that is where many of the network junctions occur. The crew size is usually small, only a few vehicles are involved, and the number and types of traffic control devices placed in the temporary traffic control zone may be minimal. As discussed in section 6G-2.a.(4), however, in this situation the reduced number of devices should be offset by the use of high-visibility devices, such as special lighting units on work vehicles. Figures TA-6, TA-10, TA-15, TA-18, TA-21, TA-22, TA-23, TA-26, and TA-33 are examples of typical applications for utility operations. Other typicals may apply as well.

6G-7. WORK WITHIN TRAVELED WAY—RURAL OR URBAN, MULTILANE DIVIDED AND UNDIVIDED, NONACCESS CONTROLLED

This section describes typical applications for work on multilane (four or more) streets or highways. It is divided into right lane closures, left lane closures, multiple-lane closures, and closures on five-lane roadways.

Figure TA-34 illustrates a lane closing in which portable concrete barriers are used. As described in section 6F-8, portable

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barriers are not in themselves traffic control devices but, if placed along an adequate taper, transition, or tangent section, they may serve as traffic control devices to provide guidance and warning to passing traffic. In serving this traffic control function, portable barriers must be equipped with appropriate channelizing devices, delineation, and/or other traffic control devices in order to perform acceptably during day and night operations. When determined necessary by an engineering analysis, barriers should be used for added safety to prevent incursions of errant vehicles beyond their designated travel lanes. The four primary functions of barriers are as follows:

- To keep traffic from entering work areas, such as excavations or material storage sites.
- To provide protection for workers and pedestrians.
- To separate two-way traffic.
- To protect roadwork such as false work for bridges and other exposed objects.

a. Right Lane Closed

Traffic control similar to that shown in figure TA-33 may be used for undivided or divided four-lane roads. If traffic volumes are high, traffic may back up. If morning and evening peak hourly traffic volumes in the two directions are uneven and the greater volume is on the side where the work is being done, the inside lane for opposing traffic may be closed and made available to the side with heavier traffic, as shown in figure TA-31. A volume check in both directions should be made before this method is used.

If the heavier traffic changes to the opposite direction, the traffic control can be changed to allow two lanes for opposing traffic by moving the devices from the opposing lane back to the centerline. If these changes occur frequently, cones or tubes should be used at close spacing to emphasize the centerline.

b. Left Lane Closed

If the work activity can be contained entirely within the left (or inside) lane, it may be appropriate to close only that lane. Channelizing devices should be placed along the centerline and outside of the work activity to give advance warning to the opposing traffic. An alternative is to close the two center lanes, as shown in figure TA-30, to give motorists and workers additional protection and to provide easier access to the work space. Overall safety needs, evaluated on the basis of existing traffic volumes and speeds in each direction, is the main factor for determining alternatives.

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c. Multiple Lanes Closed

When the work occupies multiple lanes for one direction of traffic, the number of lanes remaining open may be reduced to one for each direction as shown in figure TA-32. A capacity analysis is necessary before this method is initiated. Traffic should be moved over one lane at a time and the tapers should be separated by a distance of 2L, as shown in figure TA-37. When both center lanes are closed, traffic controls may be used as indicated in figure TA-30. When a roadway must be closed on a divided highway, a median crossover may be used [see section 6G-9(b) and (c)]. When the directional roadway is closed, inapplicable WRONG WAY signs and markings, and other existing traffic control devices at intersections within the temporary two-lane, two-way operations section, should be covered, removed, or obliterated.

d. Five-Lane Roads

Traffic control for lane closures on five-lane urban or rural roads is similar to other multilane undivided roads. Figures TA-32 and TA-34 should be adapted for use on five-lane roads.

For short-duration and mobile operations, see figure TA-35.

6G-8. WORK WITHIN TRAVELED WAY—INTERSECTIONS

For work at an intersection, advance warning signs, devices, and markings are to be used as appropriate on all cross streets. The effect of the work upon signal operation should be considered, such as signal phasing for adequate capacity and for maintaining or adjusting detectors in the pavement.

A shoulder closing is done as shown in figure TA-4. A minor encroachment is done as shown in figure TA-6.

When a lane is closed on the approach side of an intersection, standard lane closure and taper techniques apply, as shown in figure TA-21. A turn lane may be used for through traffic.

When a lane must be closed on the far side of an intersection, that lane should be closed on the near side approach, or converted to an exclusive turn lane, as shown in figures TA-22, TA-23, TA-24, and TA-25.

If the work is within the intersection, several options exist as follows:

- Keep the work space small so that traffic can move around it, as shown in figure TA-26.

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- Use flaggers to assign the right-of-way, as shown in figure TA-27.
- Do the work in stages so the work space is kept small.
- Reduce traffic volumes by road closing or upstream diversions.

6G-9. WORK WITHIN TRAVELED WAY—FREEWAYS

Serious problems of traffic control occur under the special conditions encountered where traffic must be moved through or around temporary traffic control zones on high-speed, high-volume roadways. Although the general principles outlined in the previous sections of the manual are applicable to all types of highways, special consideration should be given to modern, high-speed, access-controlled highways to accommodate traffic in a safe and efficient manner that also adequately protects work forces. The density of traffic on these facilities requires that the most careful traffic control procedures be implemented, such as inducing critical merging maneuvers well in advance of work spaces and in a manner that creates minimum turbulence and delay in the traffic stream. These situations may require more conspicuous devices than specified for normal rural or urban street use. However, the same important basic considerations of uniformity and standardization of general principles apply for all roadways.

The year-round, night-and-day intensity of use of expressways and freeways means that there is no season during which work can be scheduled when traffic volumes and density are low. These activities therefore must be performed under extremely heavy traffic conditions.

Traffic controls for short-duration and mobile operations are shown in figure TA-35.

a. Problem Areas

The performance of work under high-speed, high-density traffic on controlled access highways is complicated by many of the design and operational features inherent to their use.

The presence of median dividers that establish separate roadways for directional traffic may also prohibit the closing of that roadway or the diverting of traffic to other lanes. A typical layout for shifting traffic lanes around a work space is shown in figure TA-36.

Lack of access to and from adjacent roadways prohibits rerouting of traffic away from the work space in many cases.

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A major consideration in the establishment of traffic control is the vehicular speed differential which exists and the limited time available for drivers to react safely to unusual conditions while still providing an activity area that protects workers. Traffic control for a typical lane closure is shown in figure TA-33. Traffic control for multiple and center lane closings is shown in figures TA-37 and TA-38. Figure TA-37 is the preferred method for closing a center lane when the open lanes have the capacity to carry traffic.

Other conditions exist where work must be limited to night hours, thereby necessitating increased use of warning lights, illumination of work spaces, and advance warning systems.

b. Two-Lane, Two-Way Traffic on One Roadway of a Normally Divided Highway

Two-lane, two-way operations (TLTWO) on one roadway of a normally divided highway is a typical application that requires special consideration in the planning, design, and construction phases. As unique operational problems (for example, increasing the risk of serious head-on collisions) can arise with the TLTWO, this typical application will be discussed here.

Before including a TLTWO in the traffic control plan for a project, careful consideration should be given to its appropriateness. The following items should be considered during the decision-making process:

- Is a suitable detour available?
- What are the characteristics of the traffic?
- Can traffic be maintained on the shoulder?
- Can temporary lanes be constructed in the median?
- Can the work be accomplished by closing only one directional lane? If this option is selected for consideration, will it result in additional hazard to temporary traffic control zone personnel?
- If a TLTWO is selected, will this result in a shorter contract time?
- Will the TLTWO allow a contractor to perform the work more efficiently and thus result in a substantial decrease in contract cost?
- What is the "track record" of similar installations?

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- Are there any width or height restrictions that would preclude the TLTWO or the use of a shoulder or the median as a temporary lane?

- What are the condition of the pavement and the shoulders in the proposed TLTWO section? Due to width restriction, traffic may drive on the shoulders, which must be structurally adequate.

The traffic control plan as shown in figure TA-39 shall include provision for separate opposing traffic whenever two-way traffic must be maintained on one roadway of a normally divided highway. The TLTWO shall be used only after careful consideration of other available methods of traffic control.

When traffic control must be maintained on one roadway of a normally divided highway, opposing traffic shall be separated either with portable barriers (concrete safety-shape or approved alternate), or with channelizing devices throughout the length of the two-way operation. The use of striping, raised pavement markers, and complementary signing, either alone or in combination is not considered acceptable for separation purposes.

Treatments for entrance and exit ramps within the two-way roadway segment of this type of work are shown in figures TA-40 and TA-41.

c. Crossovers

The following are good guiding principles for the design of crossovers:

- Tapers for lane drops should not be contiguous with crossovers.

- Crossovers should be designed for speeds not less than 10 miles per hour below the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed of the roadway, unless unusual site conditions require that a lower design speed be used.

- A full array of channelizing devices, delineators, and full-length, properly placed pavement markings are important in providing drivers with a clearly defined travel path.

- Portable concrete barriers and the excessive use of traffic control devices cannot compensate for poor geometric design of crossovers.

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- o The design of the crossover should accommodate all roadway traffic including trucks and buses.

- o A clear area should be provided adjacent to the crossover.

d. Interchanges

Access to interchange ramps on limited access highways should be maintained even if the work space is in the lane adjacent to the ramps. If access is not possible, ramps may be closed by using signs and Type III barricades. Early coordination with officials having jurisdiction over the affected cross streets is needed before ramp closings.

Egress to exit ramps should be clearly marked and outlined with channelizing devices. For long-term projects, old pavement markings should be removed and new ones placed. As the work space changes, the access area may be changed, as shown in figure TA-42. Traffic control work in the exit ramp may be handled as shown in figure TA-43.

When a work space interferes with an entrance ramp, a lane may need to be closed on the freeway. Work in the entrance ramp may require shifting ramp traffic. Traffic control for both operations is shown in figure TA-44.

6G-10. CONTROL OF TRAFFIC THROUGH INCIDENT AREAS

The primary function of traffic control at an incident area is to move traffic safely and expeditiously through or around the incident. An incident is an emergency traffic accident, natural disaster, or special event. Examples include a stalled vehicle blocking a lane, a traffic accident blocking the traveled way, a hazardous chemical spill closing a highway, floods and severe storm damage, a planned visit by a dignitary, or a major sporting event.

Emergencies and disasters may pose severe and unpredictable problems. The ability to install proper traffic control may be greatly reduced in an emergency, and any devices on hand may be used for the initial response as long as they do not themselves create unnecessary additional hazards. If the situation is prolonged, the standard procedures and devices set forth in this part of the MUTCD shall be used. Special events, on the other hand, can be properly planned for and coordinated. This part provides standards for the proper procedure for closing portions or entire roadways in conjunction with such activities.

Truck Route National Network and hazardous cargo signs are included in section 2B-43. During incidents, longer vehicles may need to follow a different route from automobiles because of bridge, weight, clearance, or geometric restrictions. Also,

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vehicles carrying hazardous materials may need to follow a different route from auto drivers.

The control of traffic through incident areas is an essential part of fire and enforcement operations. For these operations there must be adequate legislative authority for the implementation and enforcement of needed traffic regulations, parking controls, and speed zoning. Such statutes should provide sufficient flexibility in the application of traffic control to meet the needs of the changing conditions in incident areas.

Maintaining good public relations is necessary. The cooperation of the news media in publicizing the existence of, and reasons for, incident areas and their traffic control can be of great assistance in keeping the motoring public well informed.

Street or highway incident management signs fall into two major categories: regulatory signs and warning signs. Specifications for incident sign design are presented in section 6F-1.

The channelizing devices discussed in section 6F-5 should be used whenever possible. Flares may be used to initiate traffic control at all incidents or for short-term traffic control such as clearing incident sites, but should be replaced by more permanent devices as soon as practicable.

A short-term road closing caused by an incident such as a traffic accident may block the traveled way. Traffic may be detoured around the incident and back to the original roadway. The jurisdiction having control of the roadway will probably need to determine the detour route and install the signs. Large trucks are a primary concern in such a detour.

An incident such as a hazardous chemical spill may require closure of an entire highway. Local traffic can adjust to the closure, but through traffic must be guided around the incident and back to the original route.

6H. APPLICATION OF DEVICES

6H-1. TYPICAL APPLICATIONS

Section 6G contains discussions of typical activities. section 6H presents typical application diagrams for a variety of situations commonly encountered. While not every situation is addressed, the procedures illustrated can generally be adapted to a broad range of conditions. In many instances, it will be necessary to combine features from various typical application diagrams. For example, work at an intersection may present a near-side work area for one street and a far-side work area for the other street.

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These treatments are found in two different diagrams, and a third diagram shows how to handle pedestrian crosswalk closings.

Procedures for establishing temporary traffic control zones vary with such conditions as road configuration, location of the work, work activity, duration, traffic speed, traffic volume, and pedestrians. Examples presented in this chapter are guides showing how to apply principles and standards. Judgment is needed in applying these guidelines to actual situations and adjusting to field conditions. In general, the procedures illustrated represent the minimum needs for the situation depicted. Other devices may be added to supplement the devices and device spacing may be adjusted to provide additional reaction time or protection. Where the situation being addressed is less than typical, actual conditions may require fewer devices.

6H-2. GENERAL NOTES

General notes for various application categories are provided below. Numerous figures and tables found throughout part VI provide guidance for the development of traffic control plans and procedures. Several of these exhibits presented in previous chapters are repeated for convenience after the general notes. Note particularly figure VI-11, which serves as the legend for symbols used in the diagrams.

a. Work Performed on the Roadside (Outside Shoulder)

When work is being performed off the roadway (beyond shoulders yet within the right-of-way), little or no temporary traffic control may be needed. If there is no effect upon traffic, no devices are needed, but this is rarely the case. More commonly, there may be driver distraction, vehicles may be parked on the shoulder, vehicles may be accessing the work site via the highway, or equipment may on occasion need to travel on or cross the roadway to perform the work operation (e.g., mowing). Where these situations pertain, a single warning sign, such as ROAD WORK AHEAD, will generally suffice.

If vehicles are using the shoulder, a SHOULDER WORK sign is appropriate. For mowing operations, the sign MOWING AHEAD may be used. Where the activity is spread out over a distance of more than 2 miles, the sign should be repeated every 2 miles. A supplementary plate with the message NEXT [X] MILES may be placed below the initial warning sign.

b. Work Performed on Shoulders

When a highway shoulder is occupied, warning is needed to advise the driver and protect the workers. As a minimum, the single warning sign SHOULDER WORK is adequate. When work is

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performed on a paved shoulder 8 or more feet wide, a transition area is needed in which channelizing devices are placed on a taper of length that conforms to the requirements of a shoulder taper. When paved shoulders of width of 8 feet or more are closed on freeways and expressways, additional treatment is generally needed to alert traffic to the possibility of a disabled vehicle that cannot get off the traveled way. An initial general warning sign is needed (e.g., ROAD WORK AHEAD), followed by a RIGHT or LEFT SHOULDER CLOSED sign. Where the end of the shoulder closure extends beyond the distance that can be perceived by motorists, a supplementary plate bearing the message NEXT [X] FEET (or MILES) should be placed below the SHOULDER CLOSED sign.

When the shoulder is not occupied but work has adversely affected its condition, the LOW SHOULDER or SOFT SHOULDER sign should be used, if appropriate. Where the condition extends over a distance in excess of 1 mile, the sign should be repeated at 1-mile intervals. In addition, a supplementary plate bearing the message NEXT [X] MILES may be placed below the first such warning sign.

On multilane, divided highways, signs advising of shoulder work or the condition of the shoulder should be placed only on the side of the affected shoulder.

c. Mobile and Short-Duration Operations

As compared to stationary operations, mobile and short-duration operations are distinct activities that may involve different treatments. More mobile devices are needed (e.g., signs mounted on trucks), and larger, more imposing, and more visible devices can be used effectively and economically. For example, appropriately colored and marked vehicles with flashing or rotating lights, perhaps augmented with signs or arrow displays, may be used in place of signs and channelizing devices. The trade-off is economical because work duration is short. Mobility is essential, the crew is always onsite, and some of the vehicles may be required for the work activity or crew transportation. Safety is not compromised, as numerous small devices are merely replaced by fewer, more dominant and effective devices.

(1) Short Duration

Short-duration activities are generally considered to be those in which it takes longer to set up and remove the traffic control zone than to perform the work. Typically, such operations can be accomplished in 60 minutes or less.

There are hazards involved for the crew in setting up and taking down a traffic control zone. Also, as the work time is short, the time during which motorists are affected is significantly increased when additional devices are installed and removed. Considering these factors, it is generally held that

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simplified control procedures are warranted for short-duration activities. Such shortcomings may be offset by the use of other, more dominant devices, such as special lighting units on work vehicles.

(2) Mobile Operations

Mobile operations include activities that stop intermittently and then move on (e.g., pothole patching and litter pickup) and those that move continuously (e.g., pavement striping).

With operations that move slowly (less than 3 mph), it may be feasible to use stationary signing that is periodically retrieved and repositioned in the advance warning area. At higher speeds, trucks are typically used as components of the traffic control zones. Appropriately colored and marked vehicles with signs, flashing or rotating lights, and special lighting panels move as part of a train behind the work vehicles.

Mobile operations that move at speeds greater than 20 mph, such as snowplowing operations, shall have appropriate devices on the equipment, (i.e., rotating lights, signs, or special lighting), or shall use a protection vehicle with appropriate warning devices.

d. Lane Closings on Two-Lane Roads

When one lane of a two-lane road is closed, the remaining lane must accommodate both directions of travel. The typical procedure for short-term work is to utilize flaggers to alternate traffic flow, as shown in figure TA-10. For long-term operations, a temporary traffic signal, as shown in figure TA-12, is an alternative. For low traffic volumes on a minor road, where traffic may be self-regulating, the procedure illustrated in figure TA-11 may be used.

e. Lane Closings on Multilane Roads

When a lane is closed on a multilane road, a transition area containing a merging taper is needed. Typically, the advance warning area contains three warning signs, such as ROAD WORK AHEAD, RIGHT or LEFT LANE CLOSED AHEAD, and the Lane Reduction Transition sign.

When an interior lane is closed for use as a work space, consideration should be given to closing an adjacent lane also. This procedure provides additional space for vehicles and materials and facilitates the movement of equipment within the work space. On multilane undivided roads and streets where the left lane is closed, such additional space can be obtained by also closing the left lane in the opposing direction.

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f. Work Performed in the Vicinity of Intersections

The typical application diagrams contained herein depict typical urban intersections on arterial streets. Where the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated speed of traffic equals or exceeds 45 mph, additional warning signs may be needed in the advance warning area.

The typical application diagrams for intersections are classified according to the location of the work space with respect to the intersection area (as defined by the extension of curb or edge lines.) Thus, there are three classifications—near-side, far-side and in-the-intersection.

Traffic control zones in the vicinity of intersections may block movements and interfere with normal traffic flows. Such conflicts frequently occur at complex signalized intersections having such features as traffic signal heads over particular lanes, lanes allocated to specific movements, multiple signal phases, and signal detectors for actuated control. Where such potential problems exist, the traffic engineering staff having jurisdiction should be contacted.

It should be recognized that some work spaces may extend into more than one portion of the intersection. For example, work in one quadrant may create a near-side work space on one street and a far-side work space on the cross street. In such instances, the traffic control zone should incorporate features shown in two or more of the intersection and pedestrian typical application diagrams shown herein.

(1) Work Space on the Near Side of Intersections

Near-side work spaces, as depicted in figure TA-21, are simply handled as a mid-block lane closure. Where space is restricted, as with short block spacings, two warning signs may be used in the advance warning area, and a third "action-type" warning or regulatory sign (e.g., KEEP LEFT) is placed within the transition area. The one significant problem that may occur with a near-side lane closure is a reduction in capacity, which during certain hours of operation could result in congestion and backups.

(2) Work Space on the Far Side of Intersections

Far-side work spaces require additional treatment because motorists typically may enter the activity area by straight-through and left- or right-turning movements. Merging movements within the intersection should be avoided. Therefore, the applicable principle is to close any lanes on the near-side intersection approach that do not carry through the intersection as lanes shown in figures TA-22, TA-23, TA-24, and TA-25. If, however, there is a

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significant number of vehicles turning from this lane, then it may be advantageous to convert the lane to an exclusive turn lane.

(3) Work Space Within the Intersection

Figures TA-26 and TA-27 provide guidance as to applicable procedures for work performed within the intersection. When directing traffic within the intersection, consideration should be given to using a uniformed police officer.

g. Incident Management Situations

The immediate response to an emergency situation must by necessity make use of available devices and equipment. Given the opportunity, however, longer term emergencies should be treated in a manner similar to other temporary traffic control work sites.

h. Features That May Be Added to the Diagrams

The measures described below are useful in increasing conspicuity and visibility of traffic control devices.

(1) Flags on Signs

Flags may be placed above signs to enhance their target value and increase motorists' awareness. Flags are useful for daytime operations only.

(2) Flashing Lights on Signs

Portable warning lights may be placed above signs to enhance their target value and increase motorists' awareness. Type A low-intensity warning lights are effective at night. Type B high-intensity warning lights are effective for both day and night.

(3) Sign Illumination

The retroreflective material used on sign faces returns light to a light source. In some instances, vehicular headlight beams may not illuminate a sign, such as those placed on sharp curves or on crossroads. Likewise, some road users, such as pedestrians and cyclists, may have inadequate head lamps or no head lamps at all. When these situations are encountered, adequate nighttime sign visibility may be obtained using internal or external sign illumination.

(4) Lights on Channelizing Devices

For intermediate and long-term operations, consideration should be given to placing portable warning lights on

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channelizing devices. Lights are especially effective in the following applications: where new travel patterns are established at tapers, shifts, and runarounds; at road closings; on devices placed on horizontal and vertical curves; where headlights may not adequately illuminate retroreflective material on channelizing devices; and when adverse weather conditions are anticipated.

6H-3. TYPICAL APPLICATION DIAGRAMS

Table VI-4 is an index of typical applications diagrams. The remainder of the chapter contains the typical application diagrams on the right page with notes on the facing page to the left. The legend for the symbols used in the diagrams is provided as figure VI-12.

In many of the diagrams, sign spacings are indicated by letters using criteria set forth in section 6F-1. Table VI-3 in that section provides sign spacing dimensions for various area and road types. The table is repeated on the next page for ease of reference.

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Table VI-3. Suggested advance warning sign spacing

Road type	Distance between signs		
	A	B	C
Urban (low speed*)	200	200	200
Urban (high speed*)	350	350	350
Rural	500	500	500
Expressway/Freeway	1,000	1,600	2,600

Formulas for L**

SPEED	FORMULA
40 mph or less	$L = \frac{WS^2}{60}$
45 mph or greater	$L = W \times S$

* Speed category to be determined by State highway agency in cooperation with local jurisdictions.

** L = Taper length in feet.
W = Width of offset in feet.
S = Posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed in mph.

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Table VI-4. Index to typical application diagrams

Location Roadway Type Application	Duration of work	
	Stationary/* short duration***	Mobile**
Roadside (outside of shoulder) All roadways		
Work beyond the shoulder	TA-1	
Blasting zone	TA-2	
Shoulder All roadways		
Work on shoulders	TA-3	
Mobile operation on shoulder		TA-4
Shoulder closed on freeway	TA-5	
Shoulder work with minor encroachment	TA-6	
Within traveled way Rural two-lane		
Road closed with on-site detour	TA-7	
Roads closed with off-site detour	TA-8	
Roads open and closed with detour	TA-9	
Lane closure on two-lane road using flaggers	TA-10	
Lane closure on low-volume, two-lane road	TA-11	
Lane closure on two-lane road using traffic signals	TA-12	
Temporary road closure	TA-13	
Haul road crossing	TA-14	
Work in center of low-volume roads	TA-15	
Surveying along centerline of low-volume road	TA-16	
Mobile operation on two-lane road		TA-17

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Table VI-4. Index to typical application diagrams(continued)		
Location **Roadway type** **Application**	**Duration of work**	
	Stationary/ short duration	**Mobile**
Urban streets		
Lane closure on minor street	TA-18	
Detour for one travel direction	TA-19	
Detour for closed street	TA-20	
Intersections and walkways		
Lane closure near side of intersection	TA-21	
Right lane closure far side of intersection	TA-22	
Left lane closure far side of intersection	TA-23	
Half road closure far side of intersection	TA-24	
Multiple lane closures at intersection	TA-25	
Closure in center of intersection	TA-26	
Closure at side of intersection	TA-27	
Sidewalk closures and bypass walkway	TA-28	
Crosswalk closures and pedestrian detours	TA-29	
Multilane undivided		
Interior lane closure on multilane street	TA-30	
Lane closure with uneven directional on streets volumes	TA-31	
Half road closure on multilane highway	TA-32	

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Table VI-4. Index to Typical Application Diagrams (continued)

Location Roadway type Application	Duration of work	
	Stationary/ short duration	Mobile
Multilane divided		
Lane closure on divided highway	TA-33	
Lane closure with barrier	TA-34	
Mobile operation on multilane road		TA-35
Freeways		
Lane shift on freeway	TA-36	
Double lane closure on freeway	TA-37	
Interior lane closure on freeway	TA-38	
Median crossover on freeway	TA-39	
Median crossover for entrance ramp	TA-40	
Median crossover for exit ramp	TA-41	
Work in vicinity of exit ramp	TA-42	
Partial exit ramp closure	TA-43	
Work in vicinity of entrance ramp	TA-44	

*Long-term stationary: more than 3 days; Intermediate-term stationary: overnight up to 3 days; Short-term stationary: anytime, more than 60 minutes.
**Mobile: Intermittent and continuous moving.
***Short-duration: up to 60 minutes.

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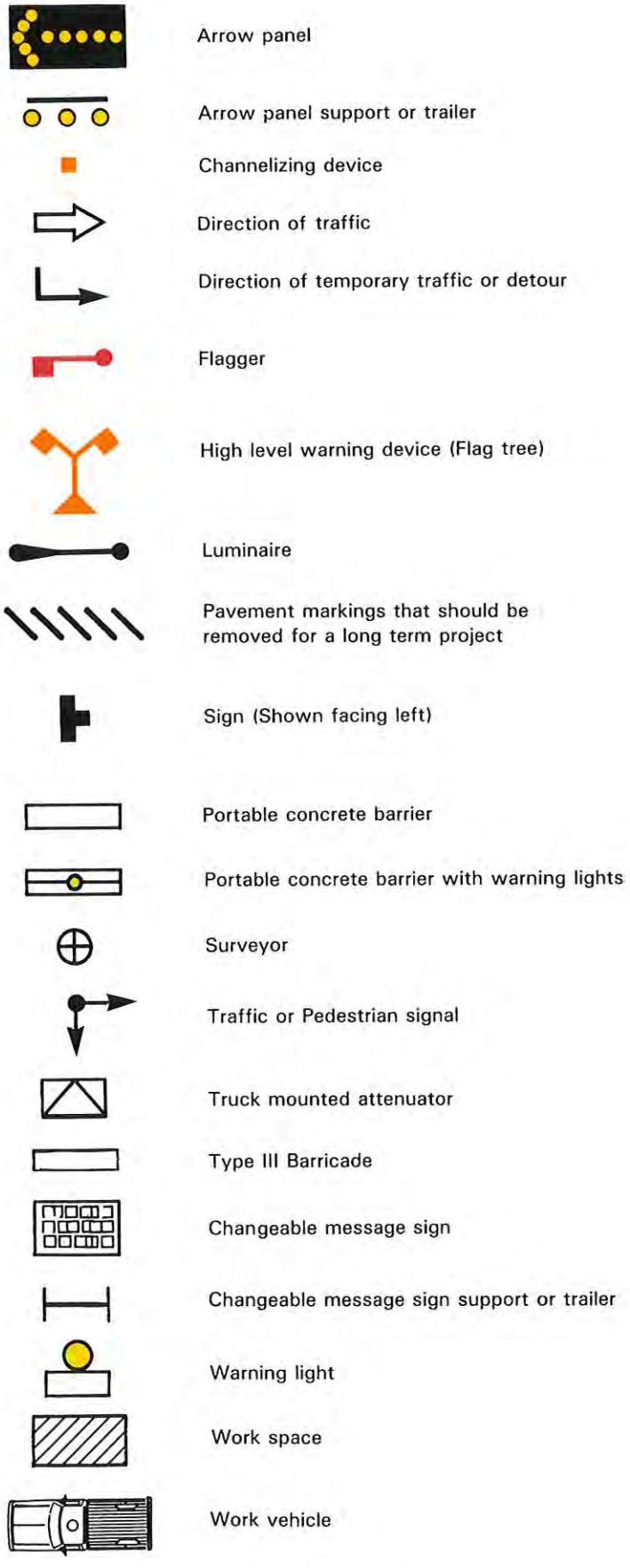

Figure VI-11. Symbols used in typical application diagrams.

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Work Beyond the Shoulder

1. The signs illustrated in this figure are not required if the work space is behind a barrier, more than 2 feet behind the curb, or 15 feet or more from the edge of any roadway.

2. The ROAD WORK AHEAD sign may be replaced with other appropriate signs, such as the SHOULDER WORK sign. The SHOULDER WORK sign may be used for work adjacent to the shoulder.

3. If the work space is in the median of a divided highway, an advance warning sign should also be placed on the left side of the directional roadway.

4. For short-term, short-duration, or mobile operation, all signs and channelizing devices may be eliminated if a vehicle with an activated flashing or revolving yellow light is used.

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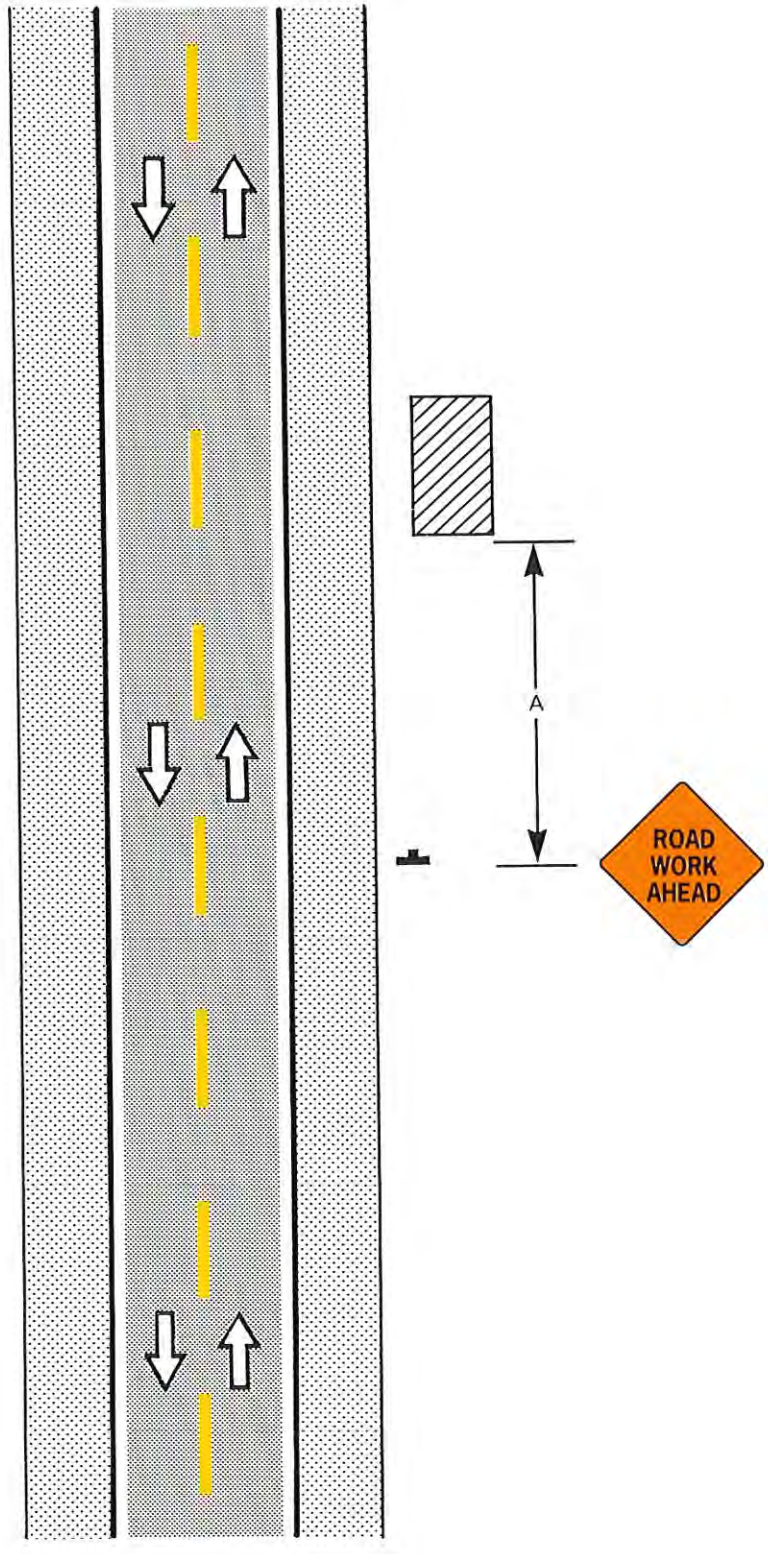

Figure TA-1. Work beyond the shoulder.

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Blasting Zone

1. Whenever blasting caps are used within 1,000 feet of a roadway, the signing shown is required. On a divided highway, the signs should be mounted on both sides of the directional roadways.

2. The signs shall be covered or removed when there are no explosives in the area or when the area is otherwise secure.

3. Whenever a side road intersects the roadway between the BLASTING ZONE AHEAD sign and the END BLASTING ZONE sign, or a side road is within 1,000 feet of any blasting cap, similar signing, as on the mainline, shall be erected on the side road.

4. Before to blasting, the blaster in charge shall determine whether highway traffic in the blasting zone will be endangered by the blasting operation. If there is danger, highway traffic shall not be permitted to pass through the blasting zone during blasting operations.

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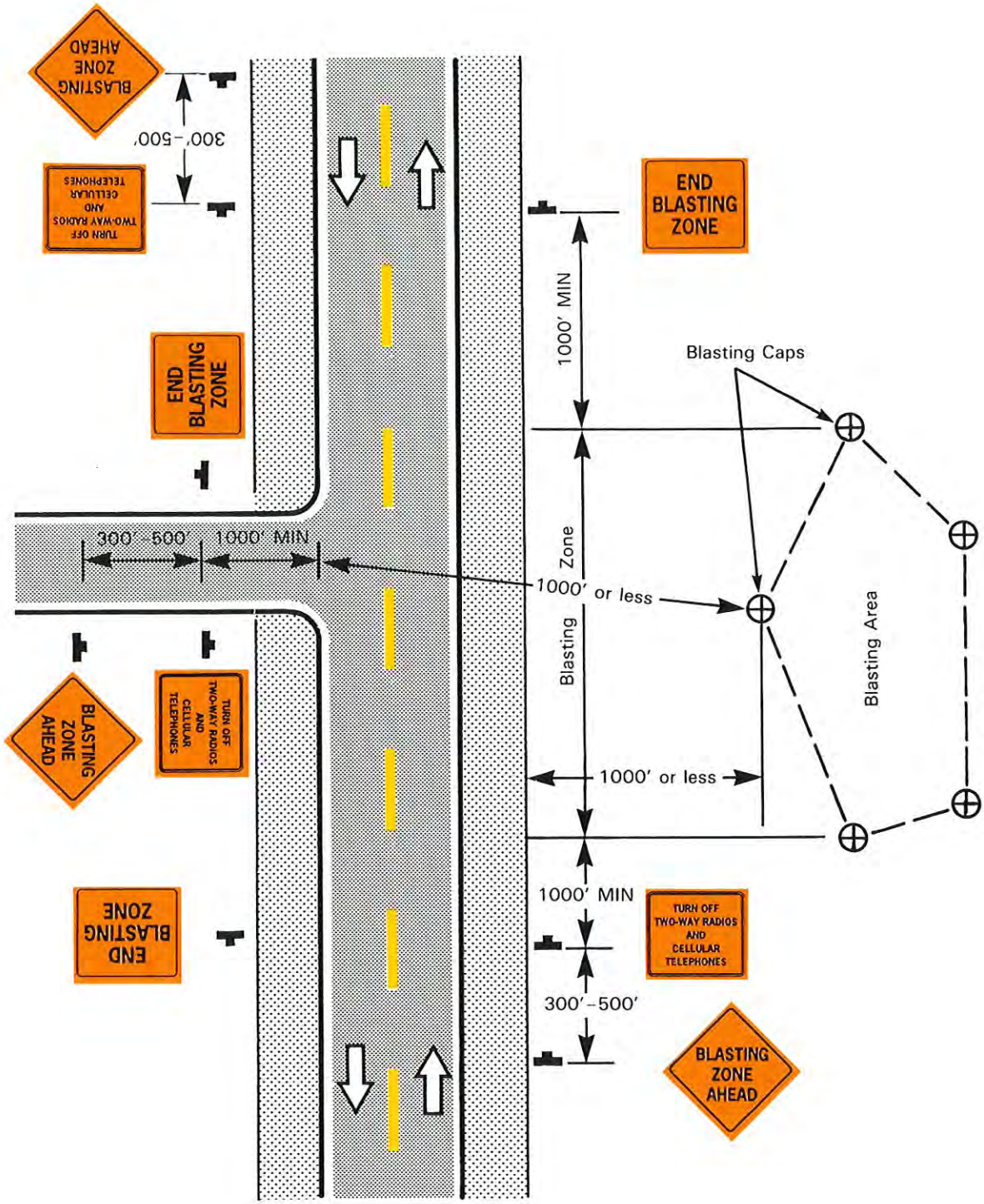

Figure TA-2. Blasting Zone.

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Work on Shoulders

1. The ROAD WORK AHEAD sign on an intersecting roadway is not required if drivers emerging from that roadway will encounter another advance warning sign before they reach this activity area.

2. A SHOULDER WORK sign should be placed on the left side of a divided or one-way roadway only if the left shoulder is affected.

3. For short-duration operations 60 minutes or less, all signs and channelizing devices may be eliminated if a vehicle with an activated flashing or revolving yellow light is used.

4. WORKER signs may be used instead of SHOULDER WORK signs.

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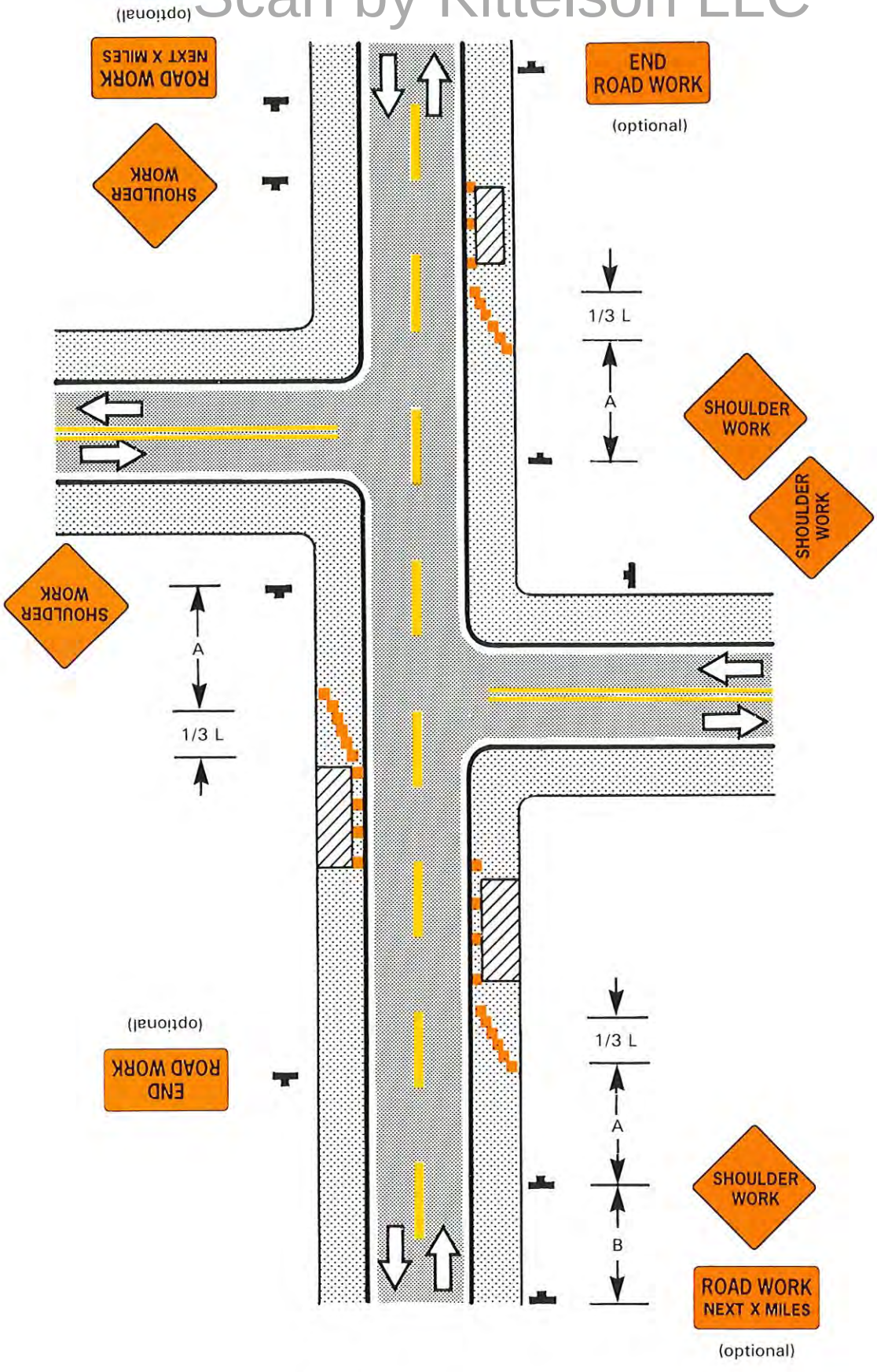

Figure TA-3. Work on shoulders.

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Mobile Operation on Shoulder

1. In situations where multiple work locations in a limited distance make it practicable to place stationary signs, the maximum spacing for the advance warning sign is 5 miles in advance of the work.

2. The length of activity area sign may be used as the stationary advance warning sign if the work locations occur over a distance of more than 2 miles.

3. Warning signs are not required if the work vehicle displays a flashing or revolving yellow light, if the distance between work locations is 1 mile or more, and if the work vehicle travels at traffic speeds between locations.

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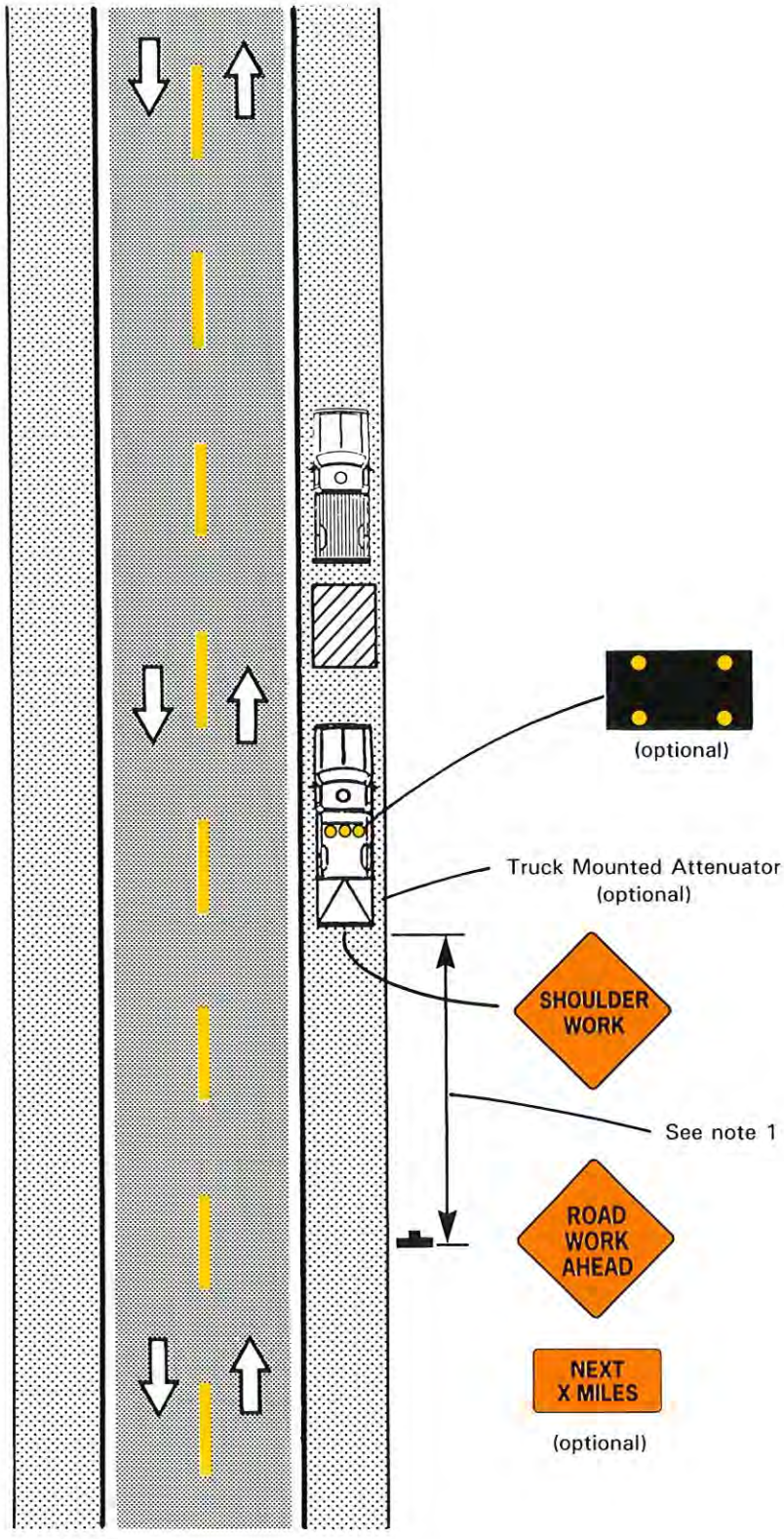

Figure TA-4. Mobile operation on shoulder.

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Shoulder Closed on Freeway

1. SHOULDER CLOSED signs should be used on limited-access highways where there is no opportunity for disabled vehicles to pull off the traveled way.

2. If motorists cannot see a pull-off area beyond the closed shoulder, information regarding the length of the shoulder closure should be provided in feet or miles, as appropriate.

3. The barrier in this diagram shows one method that may be used to close a shoulder of a long-term project. The use of a barrier should be based on the need determined by an engineering analysis. The warning lights shown on the barrier are optional.

4. Barriers should be flared beyond the clear zone to prevent vehicles from impacting their leading ends. An alternative procedure is to place an impact attenuator to protect traffic from the end of the barrier.

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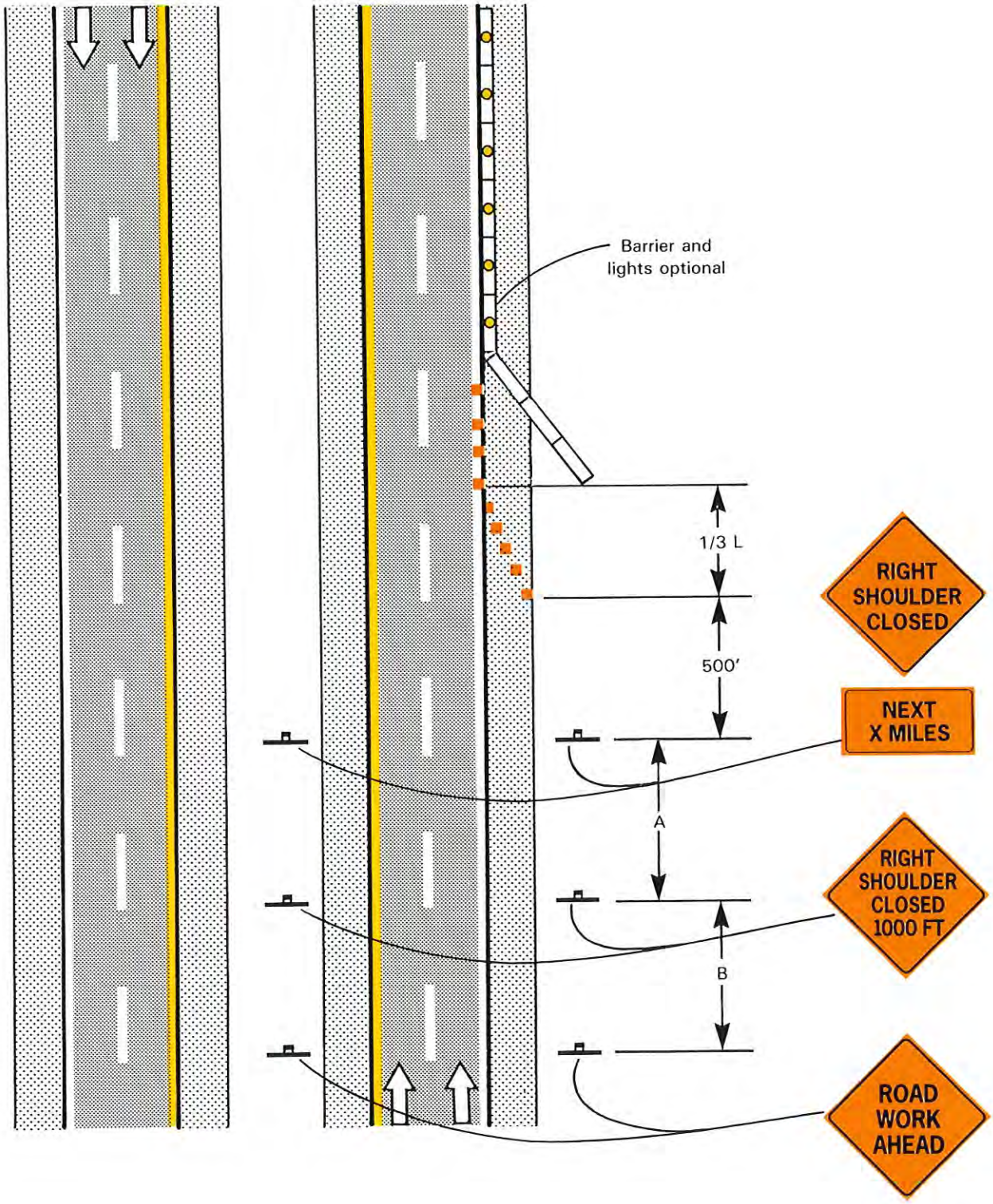

Figure TA-5. Shoulder closed on freeway.

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Shoulder Work with Minor Encroachment

1. The treatment shown may be used on a minor road having low speeds. For higher speed traffic conditions, a lane closure should be considered.

2. The procedure shown should be adequate to carry bidirectional traffic at reduced speed through the activity area, provided the lanes are at least 10 feet wide.

3. Where the opposite shoulder is suitable for carrying traffic and of adequate width, traffic lanes may be shifted by use of closely spaced channelizing devices, provided 10-foot-wide lanes are maintained.

4. Additional advance warning may be appropriate, such as a ROAD NARROWS sign.

5. Portable concrete barriers may be used along the work space.

6. The protection vehicle is optional if a taper and channelizing devices are used. For short-duration work, the taper and channelizing devices are optional if the protection vehicle with an activated flashing yellow light is used.

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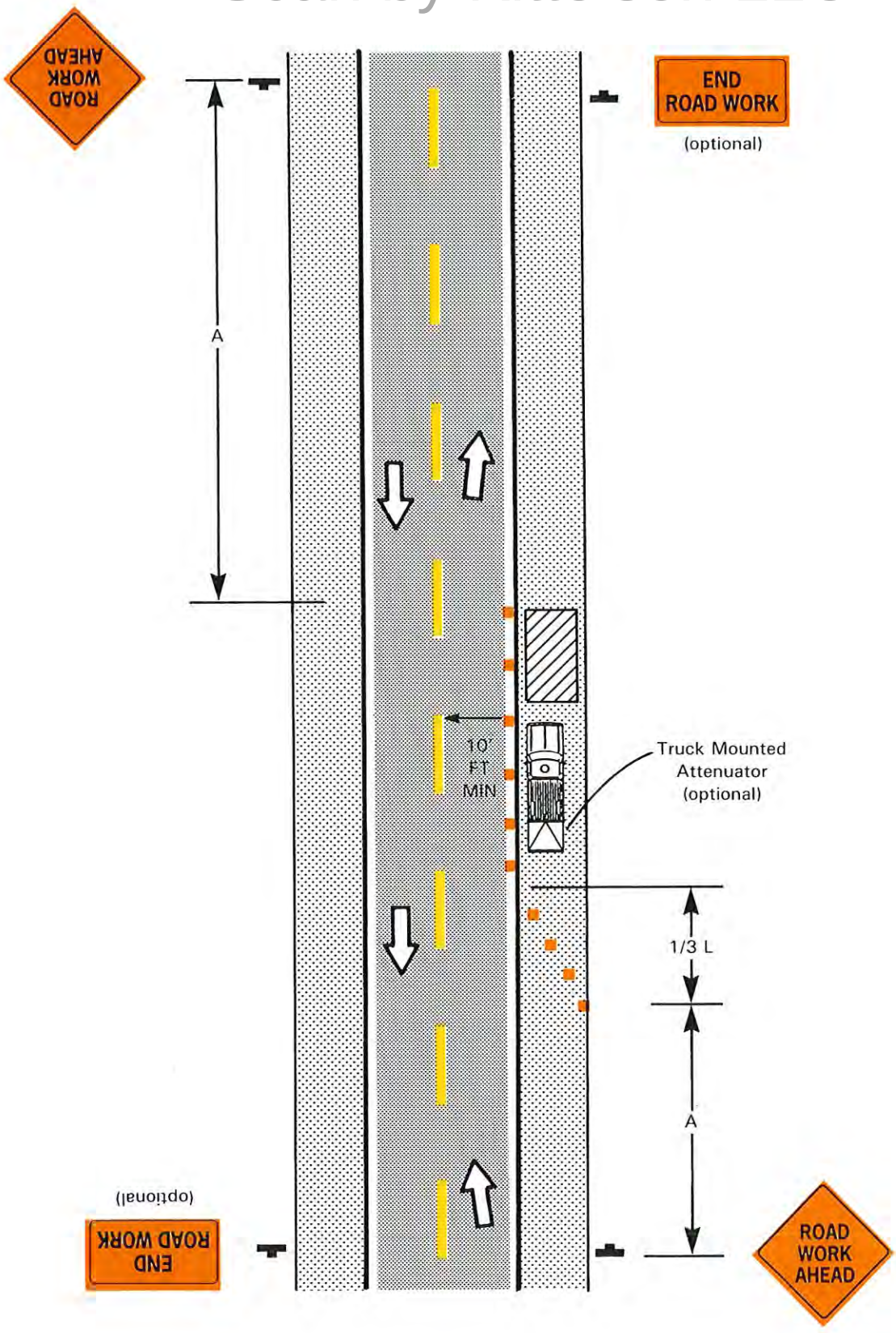

Figure TA-6. Shoulder work with minor encroachment.

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Road Closed with Diversion

1. Signs shown are for one direction of travel only.

2. Flashing warning lights and/or flags may be used to call attention to the initial warning signs.

3. Where the temporary pavement and old pavement are different colors, the temporary pavement should start on the tangent of the existing pavement and end on the tangent of the existing pavement.

4. Pavement markings that are no longer applicable shall be removed or obliterated as soon as practicable.

5. Delineators or channelizing devices may be needed along the bypass roadway.

6. If the detour is short and has sharp curves (30 mph or less), REVERSE TURN signs should be used. In addition, LARGE ARROW signs may be desirable on sharp curves.

7. For the second reverse curve, when there is insufficient advance warning distance to place a Reverse Curve or Turn sign, Large Arrow signs should be used on both curves.

8. If the tangent distance along the temporary bypass roadway is short and the curvature is sharp, two LARGE ARROW signs may be required for the second reverse curve.

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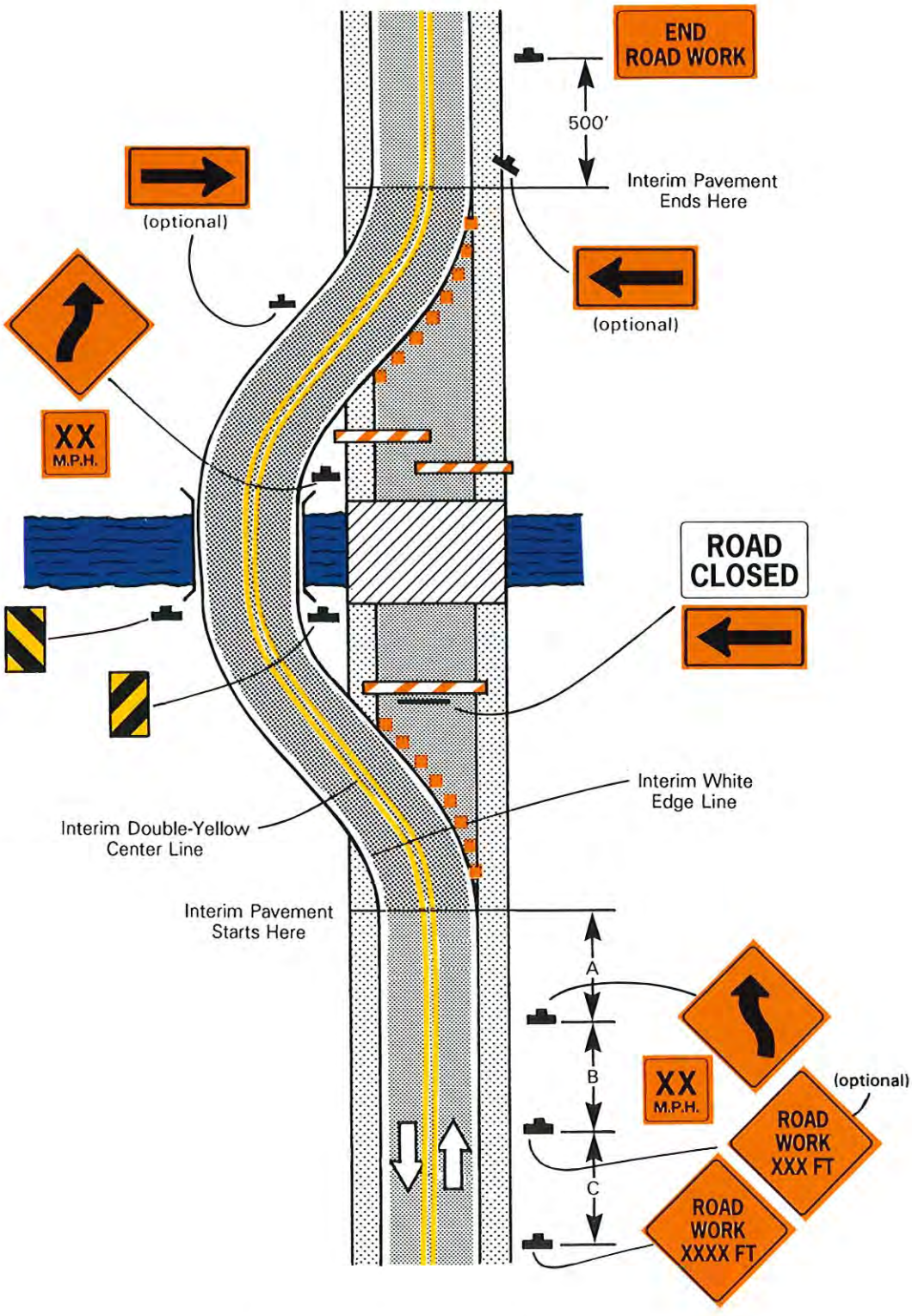

Figure TA-7. Road closed with diversion.

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Road Closed with Off-Site Detour

1. Regulatory traffic control devices are to be modified as needed for the duration of the detour.

2. If the road is opened for some distance beyond the intersection and/or there are significant origin/destination points beyond the intersection, place the ROAD CLOSED and DETOUR signs on Type III barricades located at the edge of the traveled way.

3. If the road is closed a short distance beyond the intersection and there are few origin/destination points beyond (e.g., a few residences), the ROAD CLOSED and DETOUR sign may be placed on a Type III barricade placed in the center of the roadway.

4. A route marker directional assembly may be placed on the far left corner of the intersection to augment or replace the one shown on the near right corner.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

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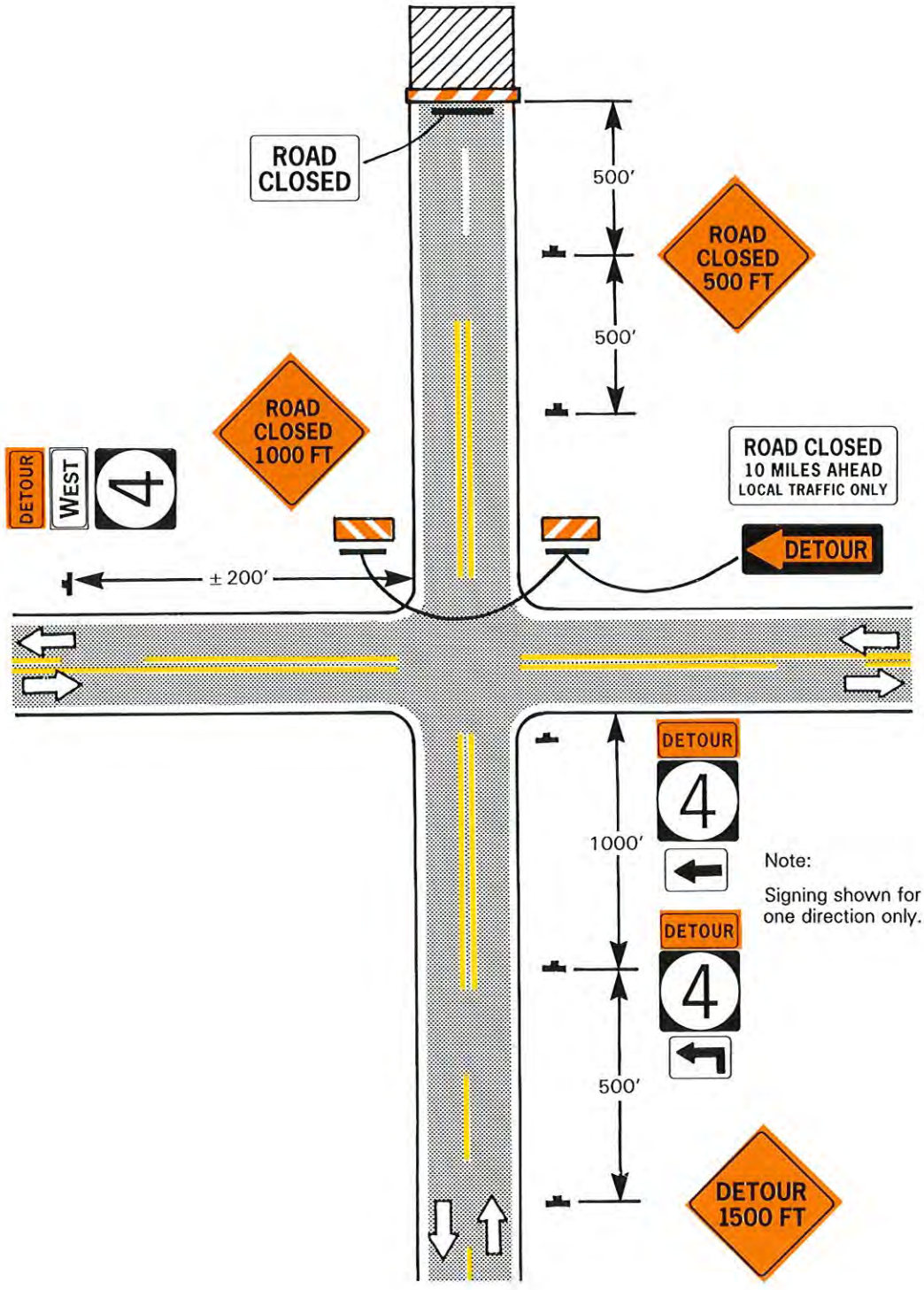

Figure TA-8. Roads closed with off-site detour.

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Roads Opened and Closed with Detour

1. Similar signs and devices shall be erected for the opposite direction.

2. STOP signs displayed to side roads should be erected along the temporary route.

3. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

4. Flashing warning lights may be used on Type III barricades.

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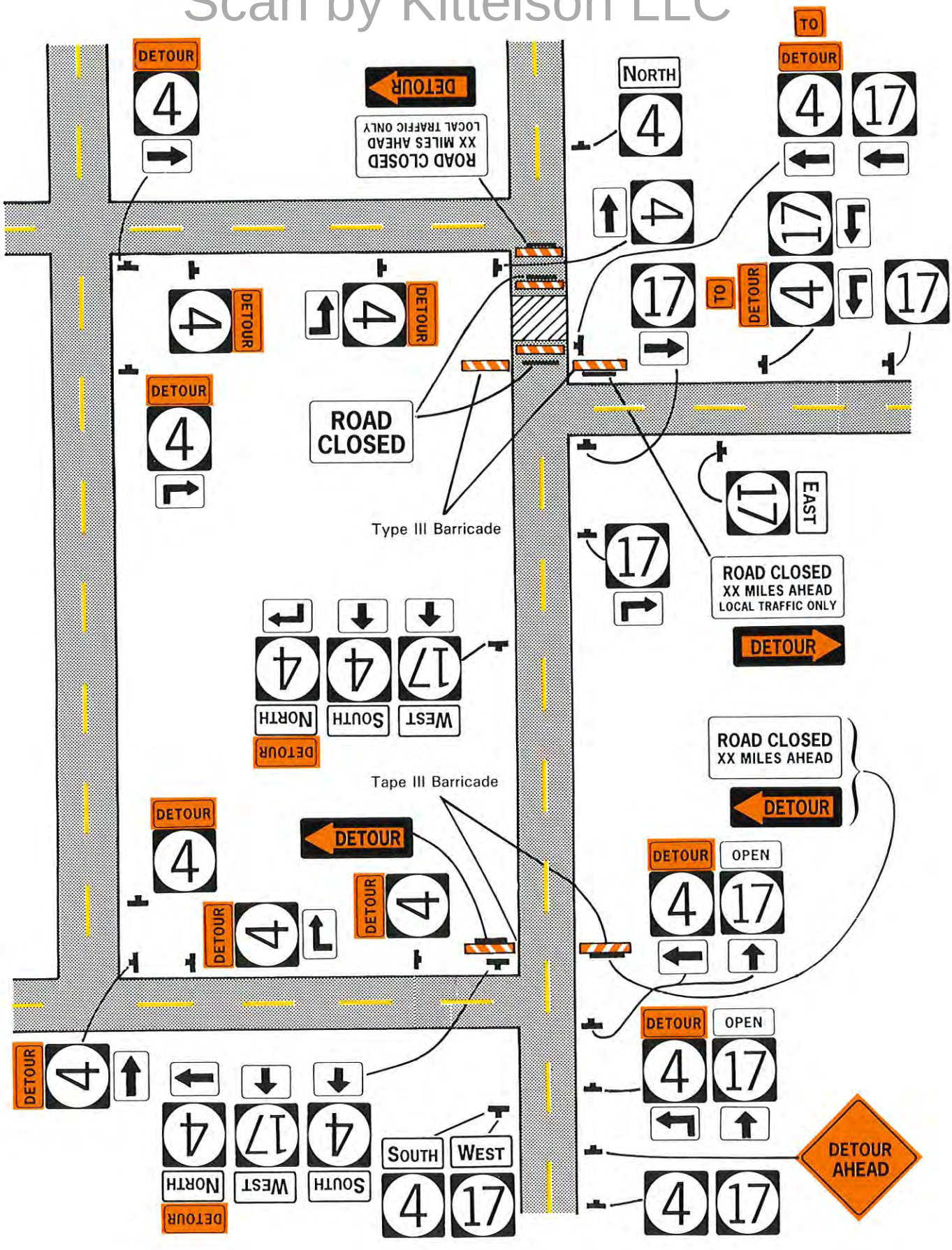

Figure TA-9. Roads open and closed with detour.

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Lane Closure on Two-Lane Road Using Flaggers

1. Floodlights should be provided to mark flagger stations at night as needed.

2. For low-volume applications, a single flagger may be adequate. Where one flagger can be used, such as for short work areas on straight roadways, the flagger must be visible to approaching traffic from both directions.

3. Channelizing devices are to be extended to a point where they are visible to approaching traffic.

4. The ROAD WORK AHEAD and the END ROAD WORK signs may be omitted for short-duration operations.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

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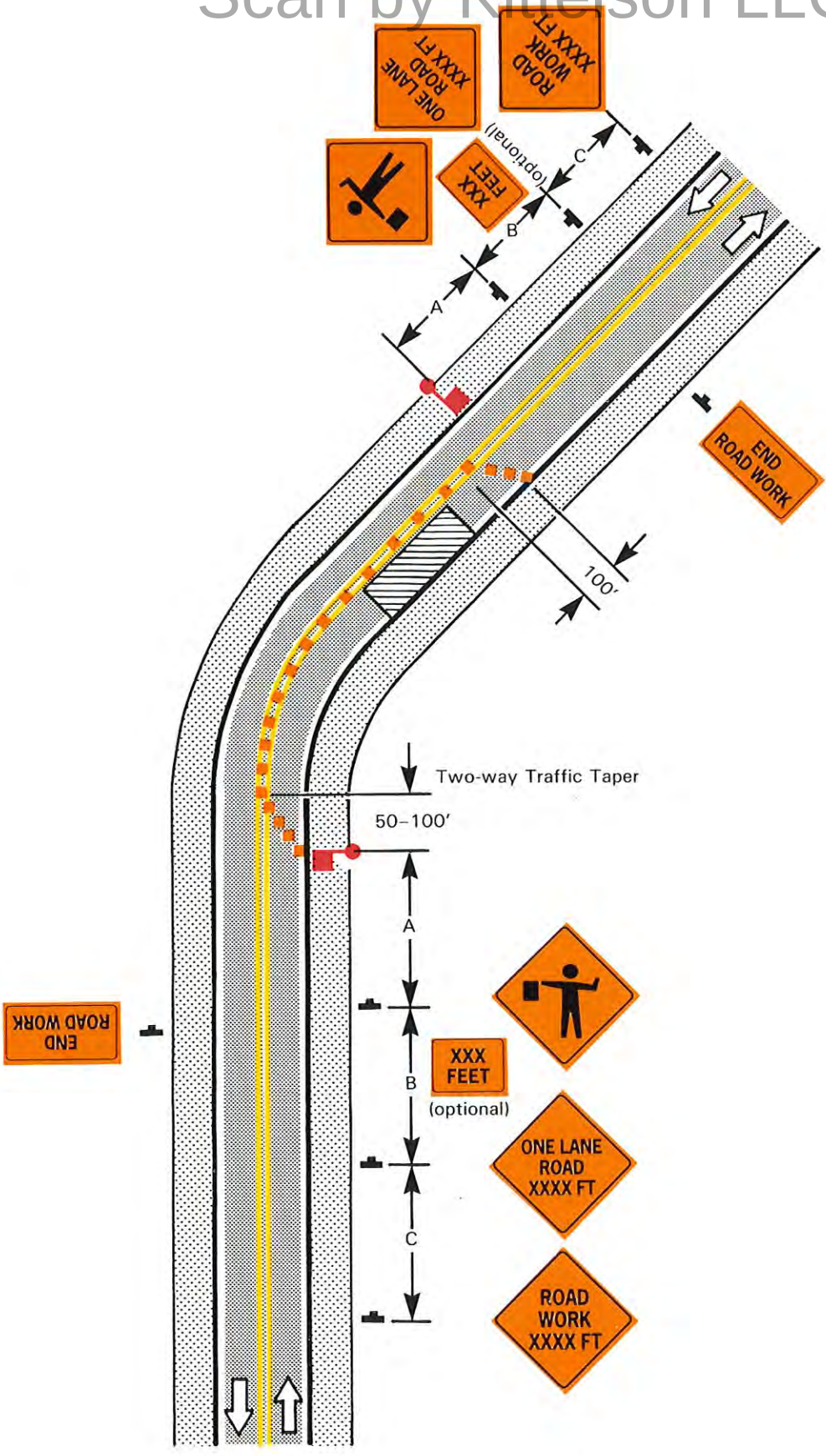

Figure TA-10. Lane closure for one lane-two way traffic control.

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Lane Closure on Low-Volume, Two-Lane Road

1. This temporary traffic control zone traffic control application may be used as an alternate traffic control plan to the lane closure with flaggers (figure TA-10), when the following conditions exist.

   a. Traffic volume is such that sufficient gaps exist for traffic that must yield.

   b. Drivers from both directions must be able to see approaching traffic through and beyond the work site.

2. The YIELD signs and YIELD AHEAD signs may be covered and flaggers used, as needed, during daylight working hours to control the flow of traffic through the work space. When flaggers are used, the ADVANCE FLAGGER sign shall be used in place of the YIELD AHEAD sign.

3. The Type A flashing warning lights may be placed on the ROAD WORK AHEAD and the ONE LANE ROAD AHEAD signs, whenever a night lane closure is necessary.

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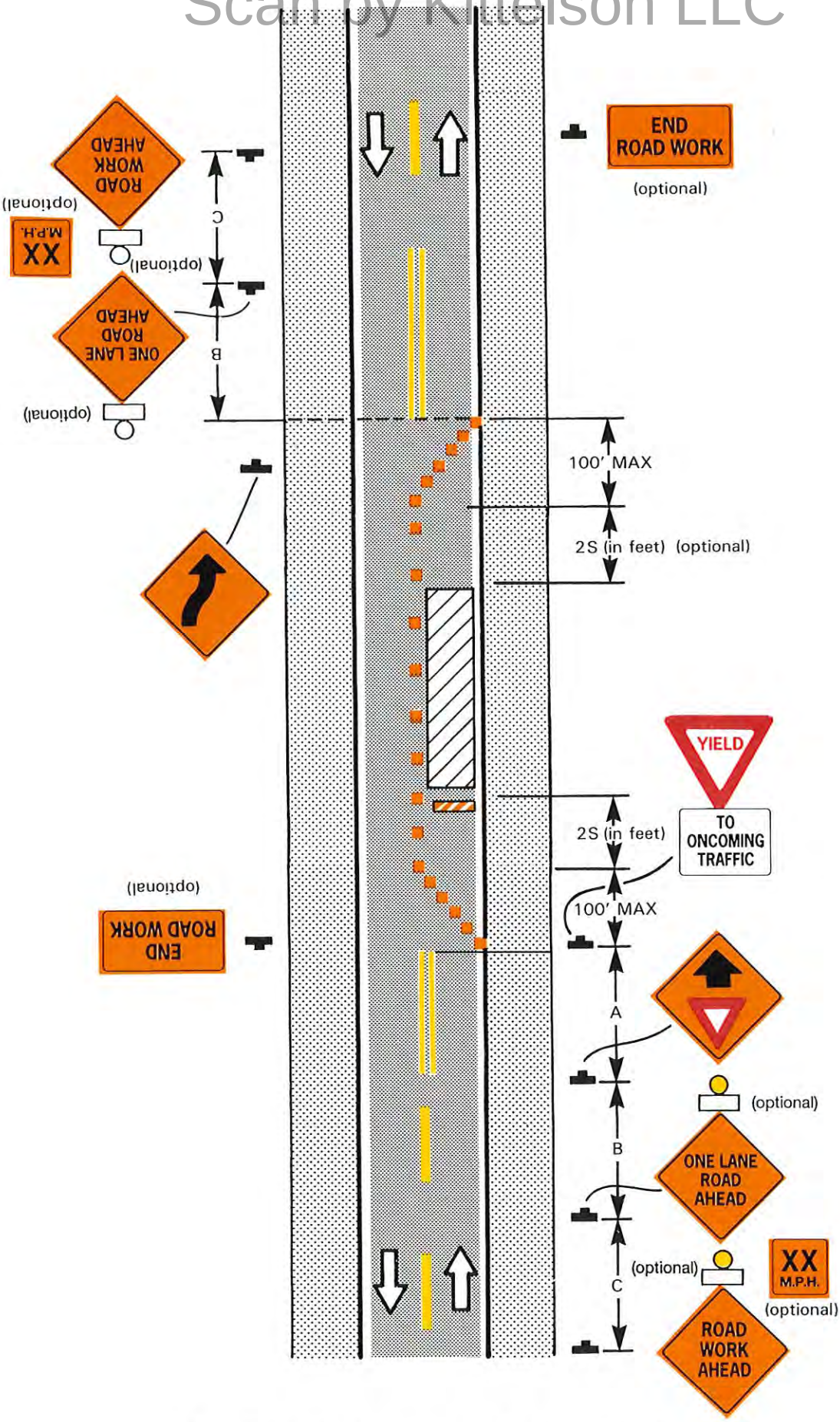

Figure TA-11. Lane closure on low-volume two-lane road.

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Lane Closure on Two-Lane Road Using Traffic Signals

1. Temporary traffic signals are preferable to flaggers for long-term projects and other activities that would require flagging at night.

2. The maximum length of activity area for one-way traffic signal control is determined by the capacity required to handle the peak hour demand. Practical maximum length is 400 feet. Signal timing shall be established by qualified personnel.

3. Signals shall be installed and operated in accordance with the requirements of part IV of this manual. Temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic signals.

4. Adequate area illumination to clearly identify both ends of the work space at night for long-term operations should be provided.

5. Stop lines 24 inches wide shall be installed. Add "no-passing" lines when necessary. Removable pavement markings may be used. Conflicting pavement markings and raised pavement marker reflectors between the activity area and the stop line shall be removed. After completion of the work, the stop lines and other temporary inapplicable pavement markings shall be removed.

6. The Type A flashing warning lights shown on the ROAD WORK AHEAD and the ONE LANE ROAD AHEAD signs may be used whenever a night lane closure is necessary. Type B lights may be used to also increase the daytime target value of the signs.

7. The horizontal or vertical alignment of the roadway may require adjustments in the location of the advance warning signs (the distances shown for advance warning sign spacings are minimums). The vertical alignment of the roadway may require adjustments in the height of the signal heads.

8. When the signal is changed to a flash condition either manually or automatically, red shall be flashed to both approaches.

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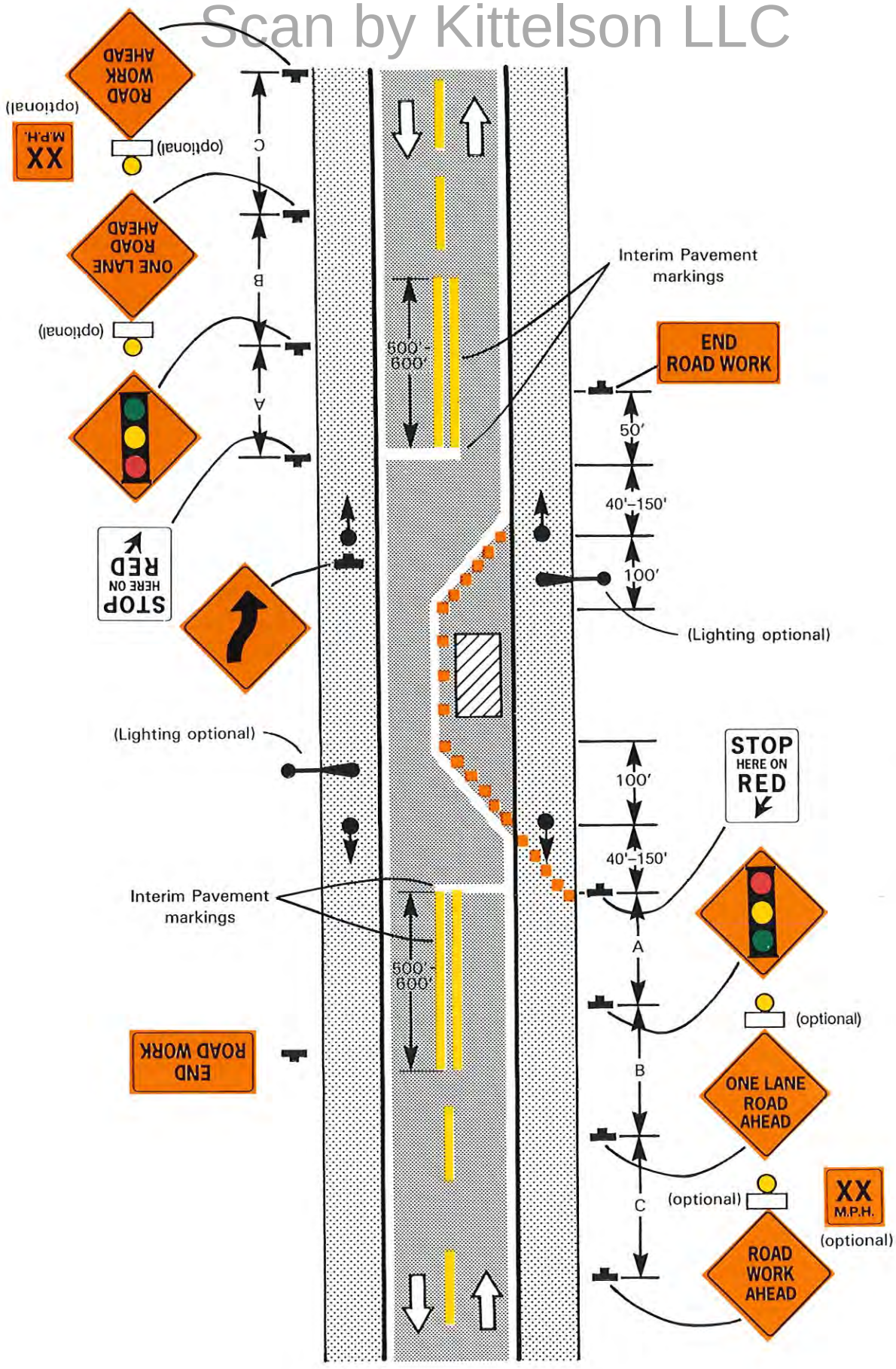

Figure TA-12. Lane closure on two-lane road using traffic signals.

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Temporary Road Closure

1. Conditions represented are for work that requires closings during daytime hours only.

2. This application is intended for a planned temporary closing not to exceed 15-20 minutes.

3. The flaggers shall stop the first vehicle from the position shown, then move to the centerline to stop approaching traffic.

4. For high-volume roads, a police patrol car and/or a changeable message sign may be added.

5. A changeable message sign may be used in place of the initial warning sign.

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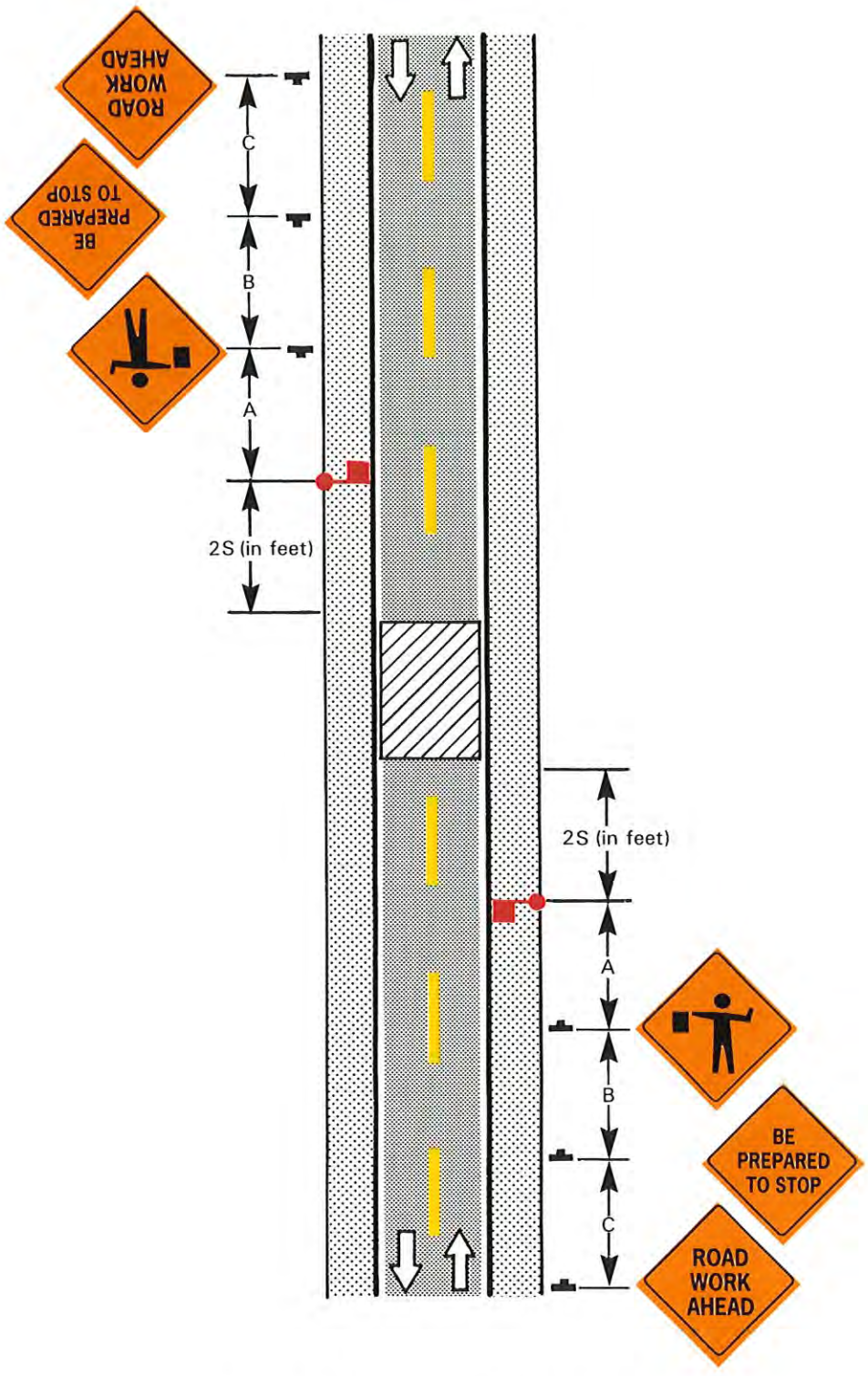

Figure TA-13. Temporary road closure.

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Haul Road Crossing

This diagram shows two different methods of traffic control—flagging and a temporary traffic signal. The method selected is to be used in both directions.

Unsignalized Crossing

1. This typical application diagram as shown is intended for short-term use during daylight hours.

2. When the haul road is not in use, Type III barricades shall be in place. ADVANCE FLAGGER signs shall be covered.

3. The flagger shall stop the first vehicle from the position shown, then move to the centerline to stop approaching traffic.

Signalized Crossing

1. Dashed yellow centerline, if existing, between the stop lines shall be removed before the beginning of roadwork and replaced before opening to normal traffic.

2. When the haul road is not in use, Type III barricades shall be in place. The SIGNAL AHEAD and STOP HERE ON RED signs and traffic signals shall be covered or hidden from view.

3. Traffic signals shall be two-direction type with push-button activation. The temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic signals as described in part IV of this manual.

Floodlighting

1. Floodlights should be used to illuminate haul road crossings where existing light is inadequate.

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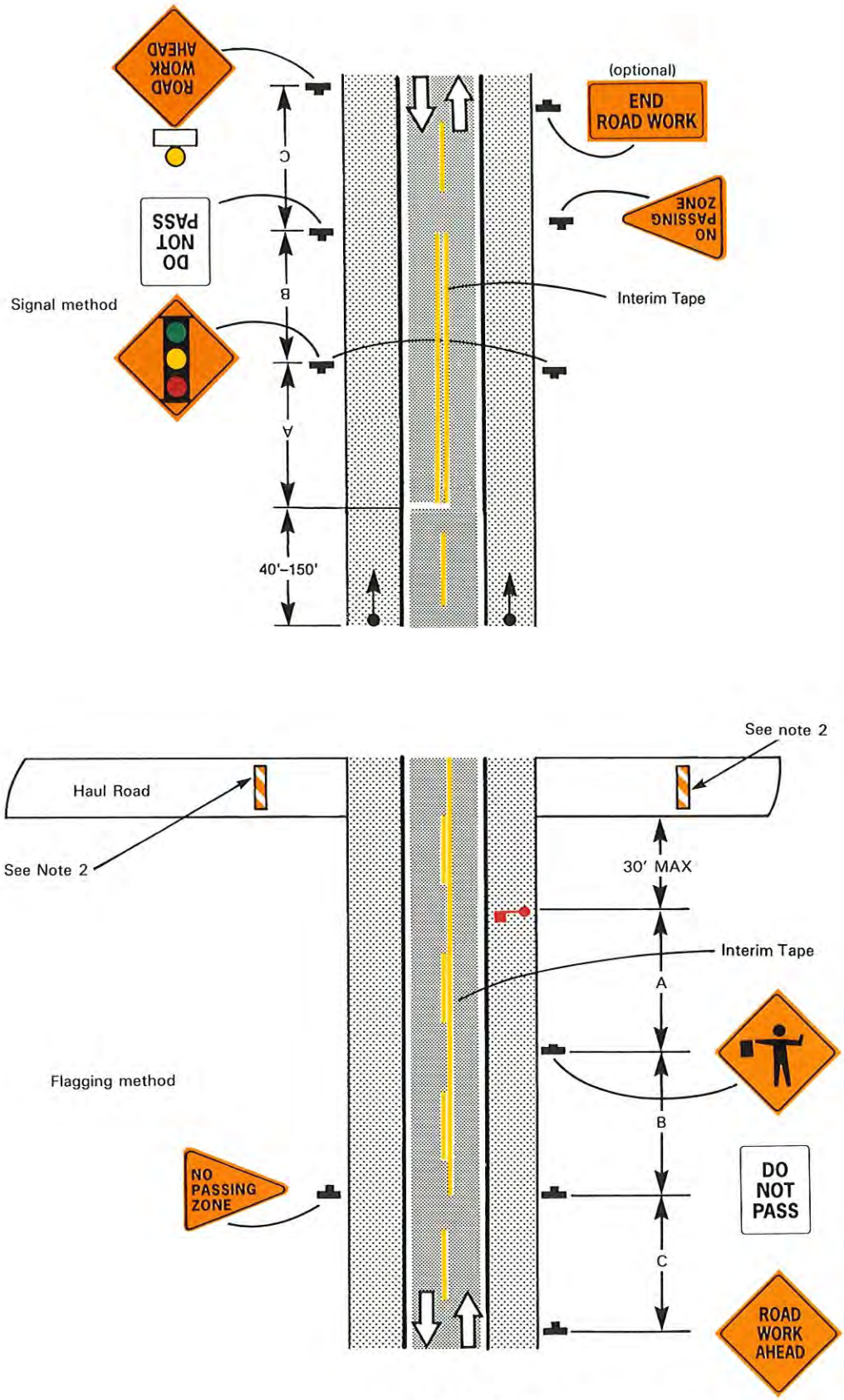

Figure TA-14. Haul road crossing.

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Work in Center of Low-Volume Road

1. The lanes on either side of the center work space should have a minimum width of 10 feet, as measured from the near edge of the channelizing devices to the edge of pavement, or the outside edge of paved shoulder.

2. A minimum of six channelizing devices should be used for each taper. However, a work vehicle displaying a flashing or revolving yellow light may be used instead of the tapers.

3. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

4. If the closure continues overnight, warning lights may be used to mark channelizing devices.

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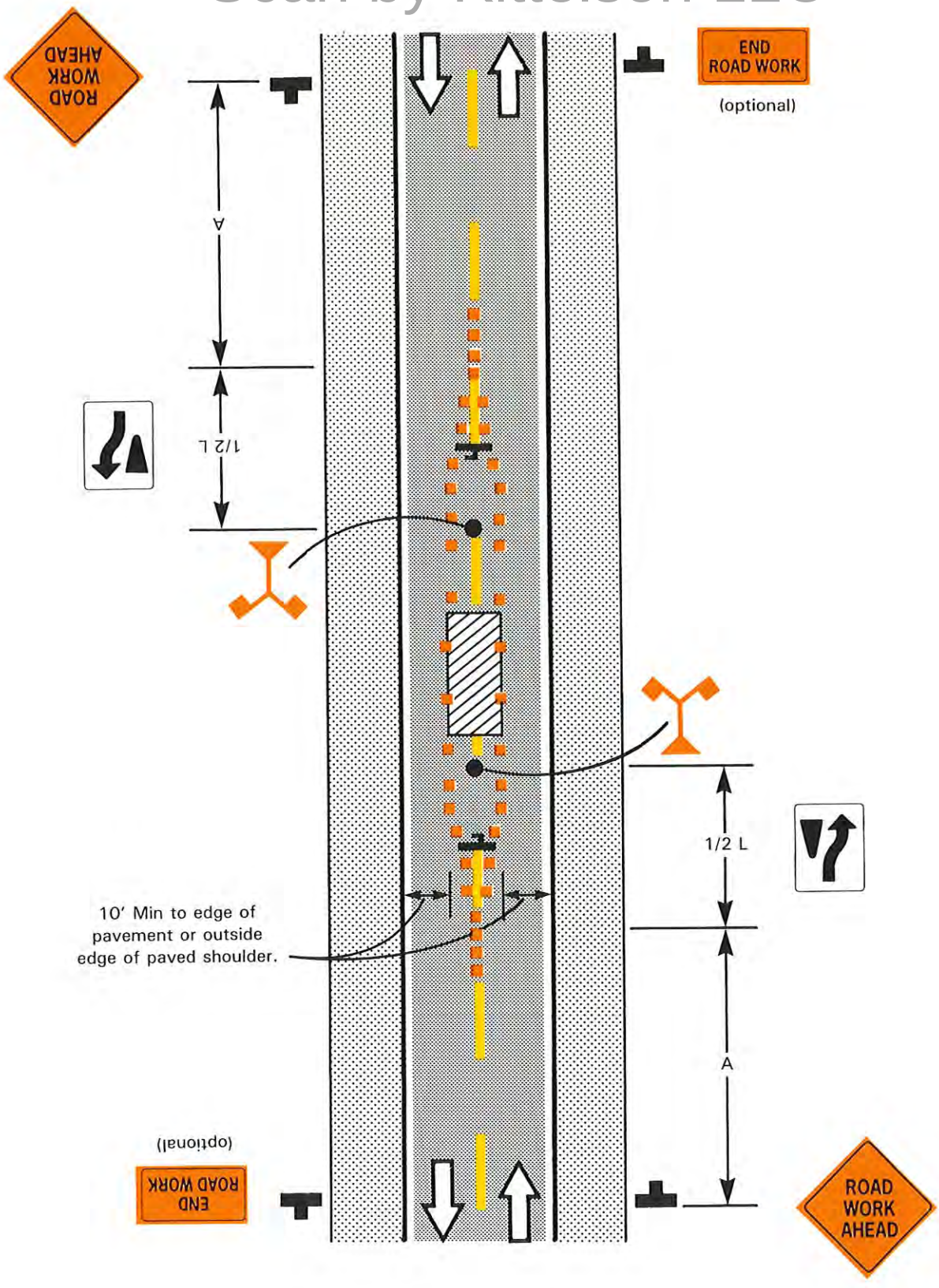

Figure TA-15. Work in center of low-volume road.

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Surveying Along Centerline of Low-Volume Road

1. The same treatment is required in both directions.
2. Cones should be placed 6 inches to 12 inches on either side of the center line.
3. Maximum spacing between cones is 100 feet.
4. For a survey along the edge of the road or along the shoulder, the advance signing remains the same. For this situation, place cones along the edge line. A flagger is not required for work along the shoulder.
5. Cones may be omitted for a cross-section survey.
6. For surveying on the centerline of a high-volume road, close one lane, using the procedure illustrated in figure TA-10.
7. ROAD WORK AHEAD signs may be used in place of SURVEY CREW AHEAD signs.
8. A flagger should be used to protect people who must work with their backs to traffic. A high-level warning device may be used to protect a surveying device, such as a target on a tripod. Workers in the roadway should wear high-visibility clothing.
9. Flags may be used to call attention to the advance warning signs.

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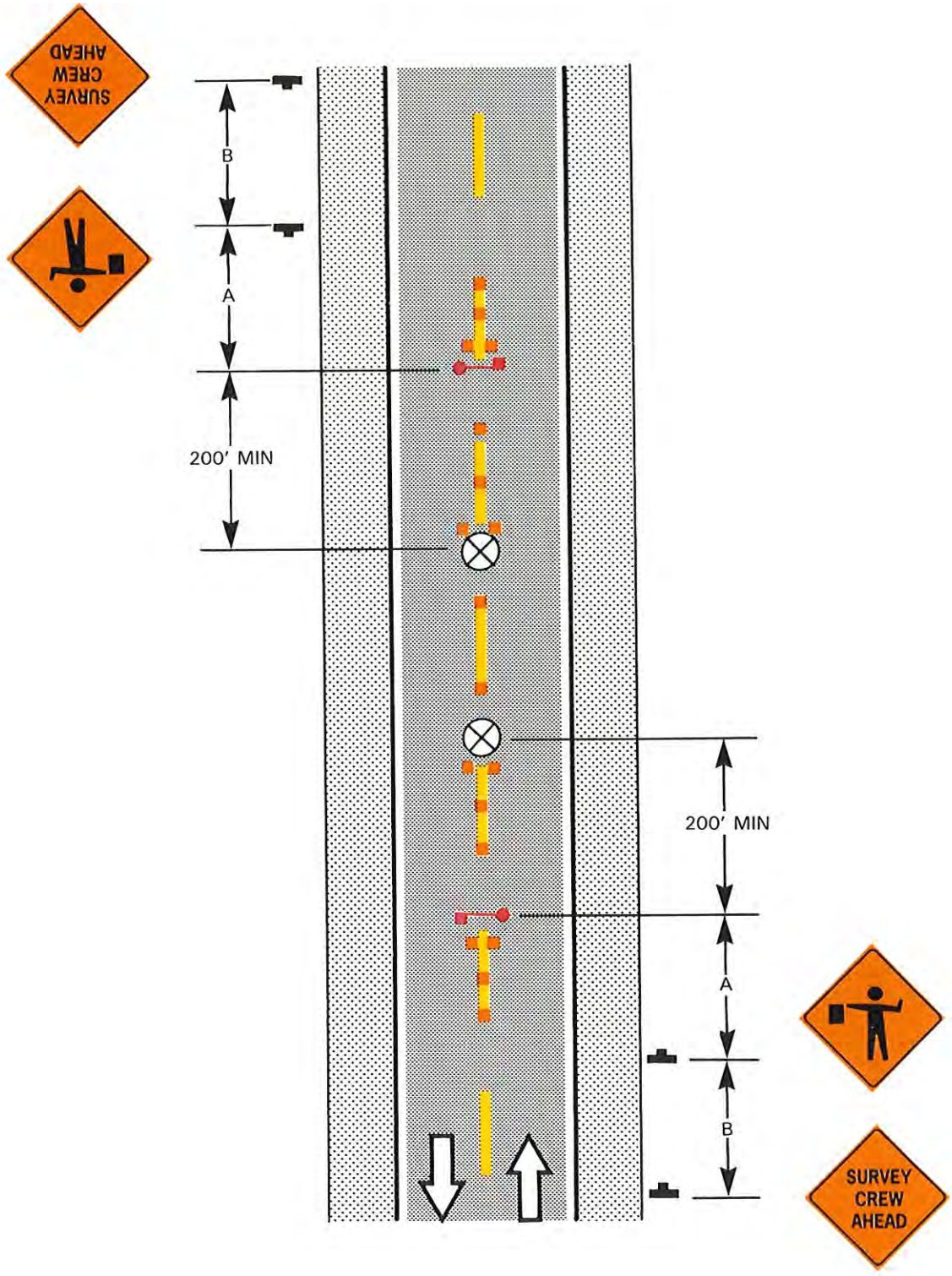

Figure TA-16. Surveying along centerline of low-volume road.

Scan by Kittelson LLC

Mobile Operations on Two-Lane Road

1. Where practicable and when needed, the work and protection vehicles should pull over periodically to allow traffic to pass. If this can not be done frequently, as an alternative, a DO NOT PASS sign may be placed on the rear of the vehicle blocking the lane.

2. The distance between the work and protection vehicles may vary according to terrain, paint drying time, and other factors. Protection vehicles are used to warn traffic of the operation ahead. Whenever adequate stopping sight distance exists to the rear, the protection vehicle should maintain the minimum distance and proceed at the same speed as the work vehicle. The protection vehicle should slow down in advance of vertical or horizontal curves that restrict sight distance.

3. Additional protection vehicles to warn and reduce the speed of oncoming or opposing traffic may be used. Police patrol cars may be used for this purpose.

4. A truck-mounted attenuator (TMA) shall be used on the protection vehicle and should be considered on the work vehicle.

5. The work vehicle shall be equipped with beacons, and the protection vehicles shall be equipped with a TMA and two high-intensity flashing lights mounted on the rear, adjacent to the sign. Protection and work vehicles should display flashing or rotating beacons both forward and to the rear.

6. Vehicle-mounted signs shall be mounted with the bottom of the sign, at a minimum height of 4 feet above the pavement. Sign legends shall be covered or turned from view when work is not in progress.

7. Arrow displays are optional and should be Type B, 60 inches by 30 inches.

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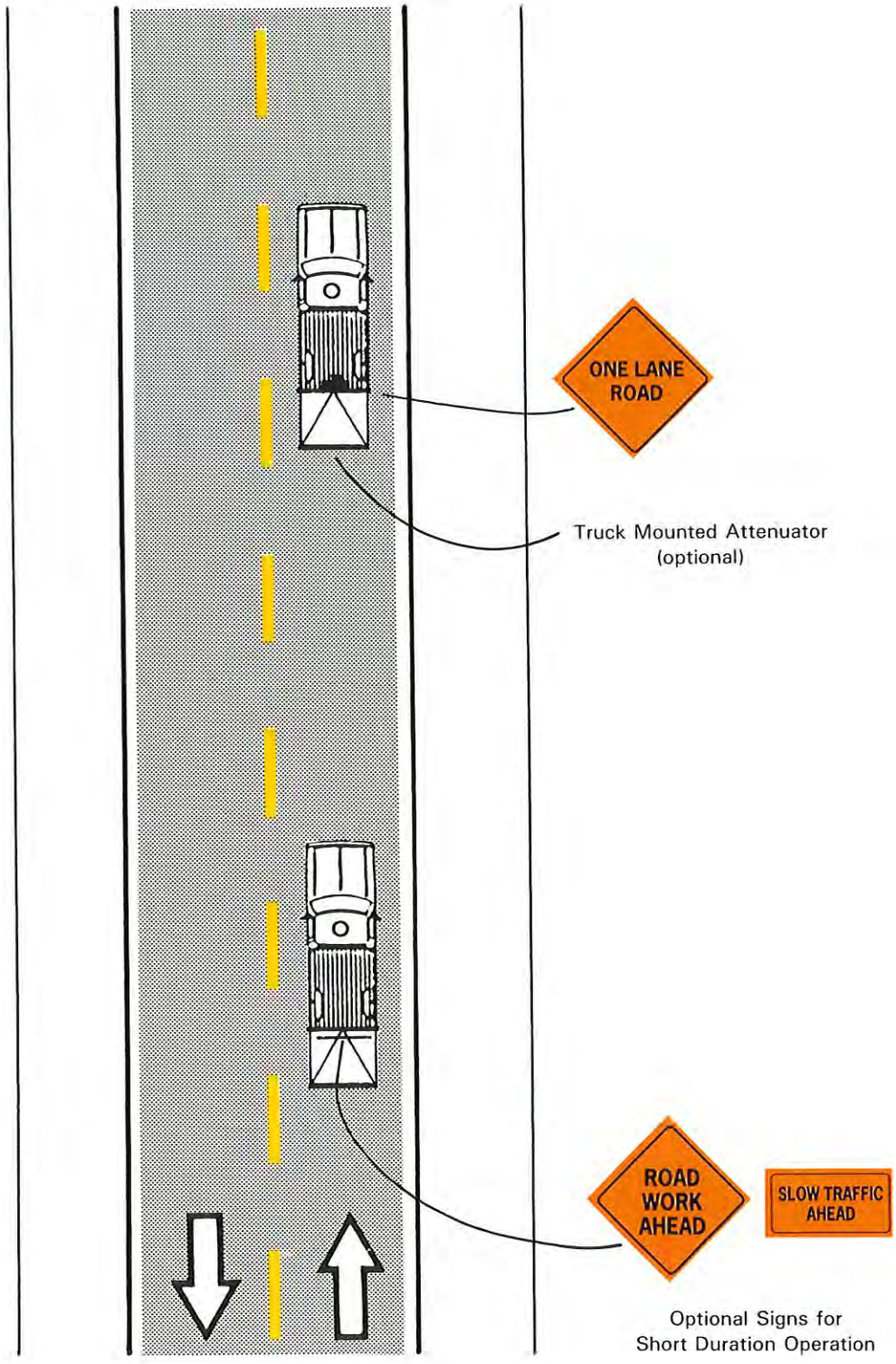

Figure TA-17. Mobile operations on two-lane road.

Scan by Kittelson LLC

Lane Closure on Minor Street

1. The traffic control procedure shown is appropriate only for low-volume, low-speed facilities, such as local residential streets. With few exceptions, this procedure is not to be used in rural areas. Typical applications of traffic control devices on other roadways are shown in figures TA-21, TA-22, and TA-23.

2. Traffic can regulate itself when volumes are low and the length of the work space is short, thus enabling drivers to readily see the roadway beyond.

3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

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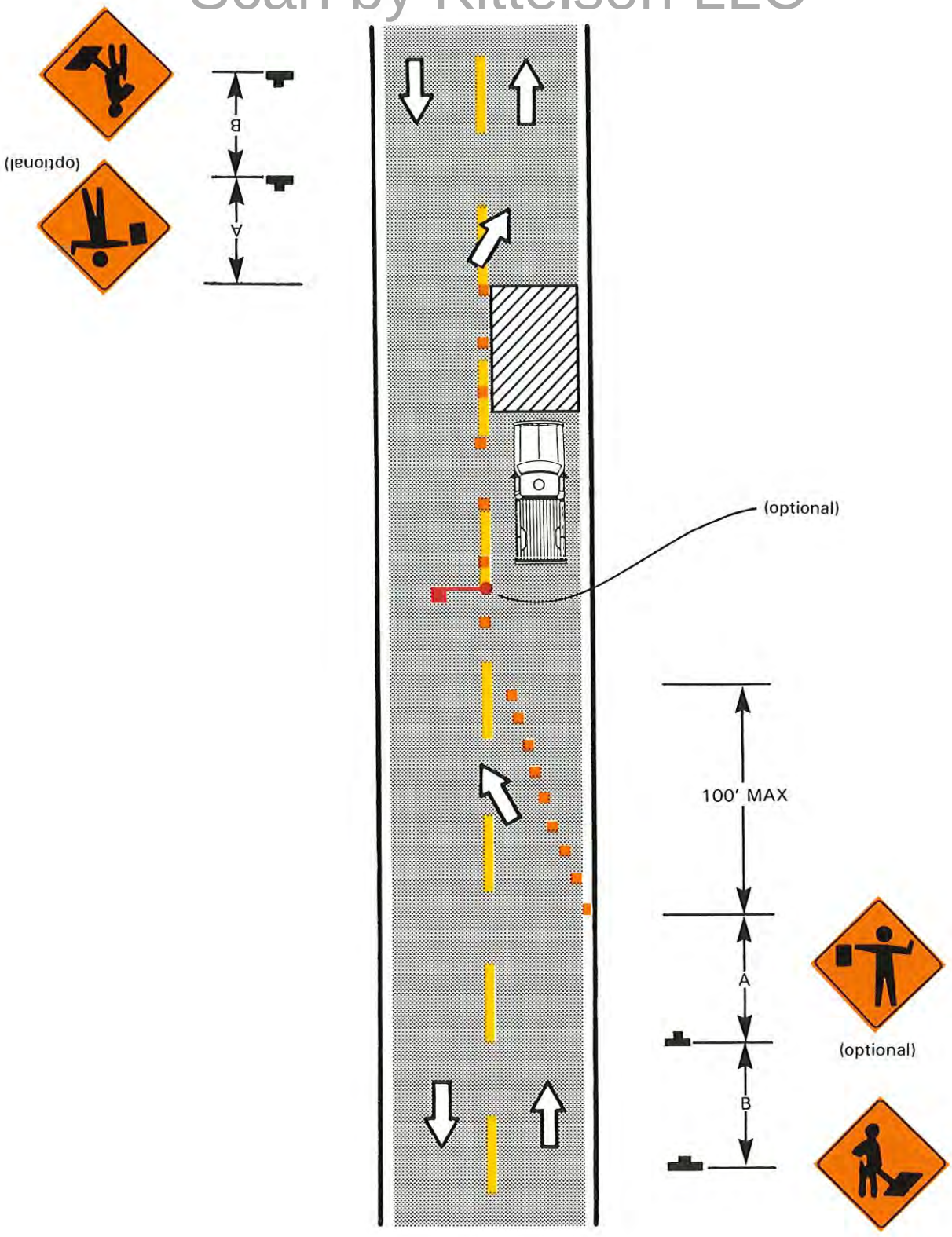

Figure TA-18. Lane closure on minor street.

Scan by Kittelson LLC

Detour for One Travel Direction

1. The STREET CLOSED sign may be used in place of ROAD CLOSED.

2. The use of a street name sign mounted with the M4-9 DETOUR sign is optional. When used, the Street Name plate is placed above the Detour sign. The plate may have either a white-on-green or a black-on-orange legend.

3. Additional DO NOT ENTER signs may be desirable at intersections with intervening streets.

4. Warning lights may be used on Type III barricades.

5. M4-9 DETOUR signs may be located on the far side of intersections.

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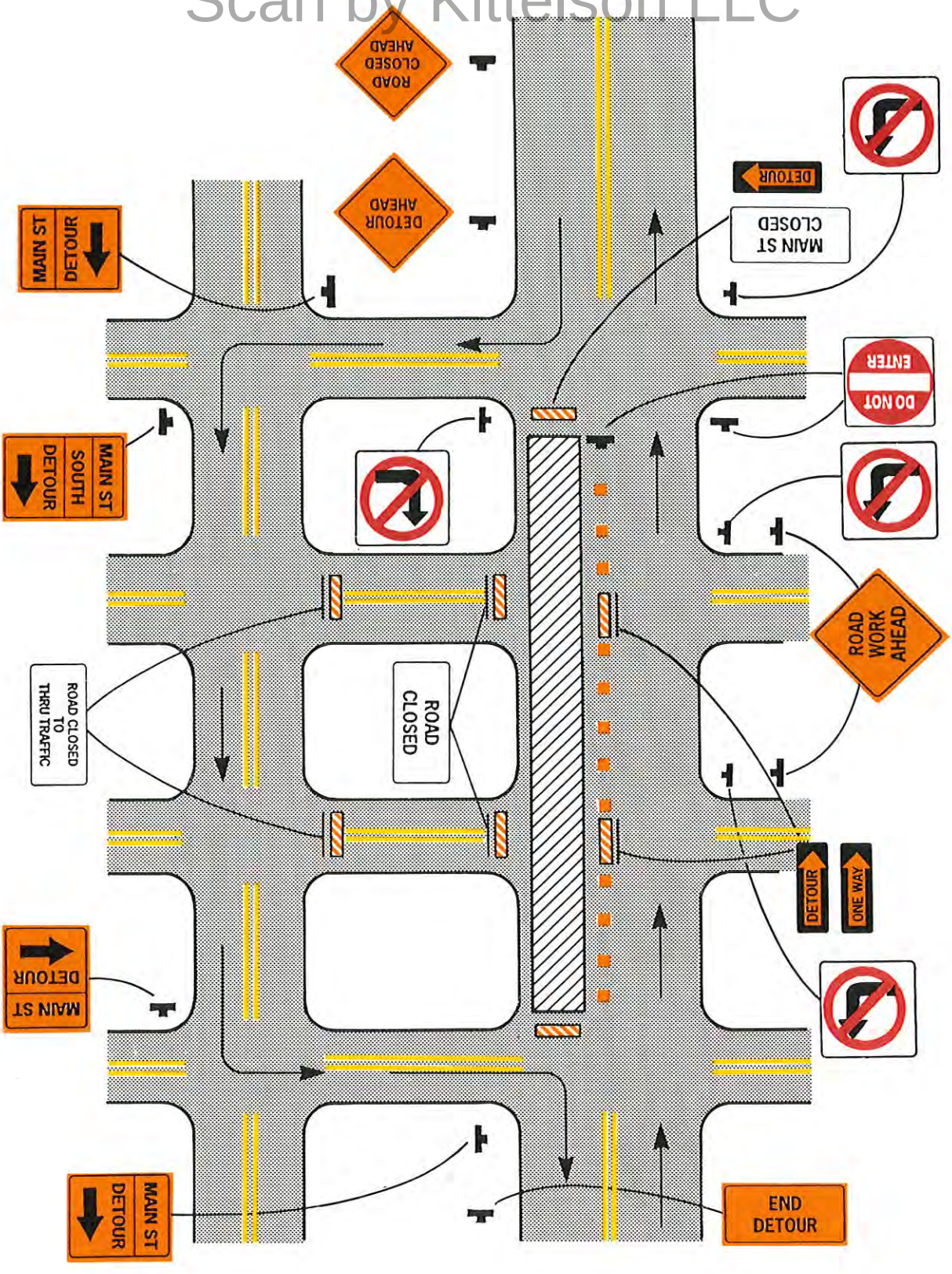

Figure TA-19. Detour for one travel direction.

Scan by Kittelson LLC

Detour for Closed Street

1. Display similar signs and devices for the opposite movement.

2. Use this plan for city streets and for county or township roads. See figure TA-9 for the procedure for detouring a numbered highway.

3. The use of a street name sign mounted with the M4-9 DETOUR sign is optional. When used, the street name plate is placed above the DETOUR sign. The plate may have either a white-on-green or a black-on-orange legend.

4. An M4-9 DETOUR sign with an advance turn arrow may be used in advance of a turn. On multilane streets, such signs should be used.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

6. Warning lights may be used on Type III barricades.

7. M4-9 DETOUR signs may be located on the far side of the intersections.

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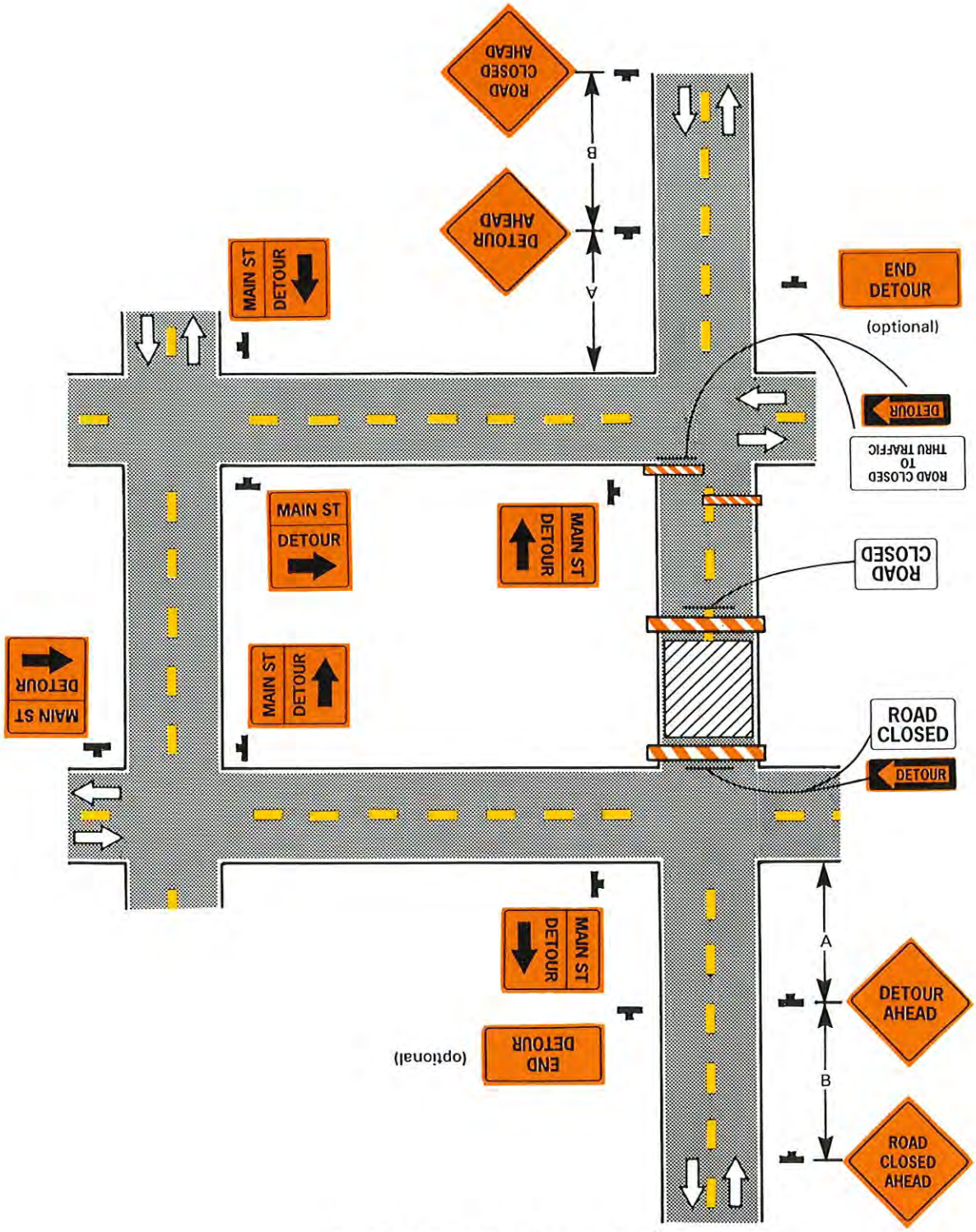

Figure TA-20. Detour for closed street.

Scan by Kittelson LLC

Lane Closure Near Side of Intersection

1. If the work space extends across the crosswalk, then close the crosswalk using the procedure and devices shown in figure TA-29.

2. The merging taper may direct traffic into either the right or left lane but not both. In this typical, a left taper should be used so that right-turn movements will not impede traffic.

3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

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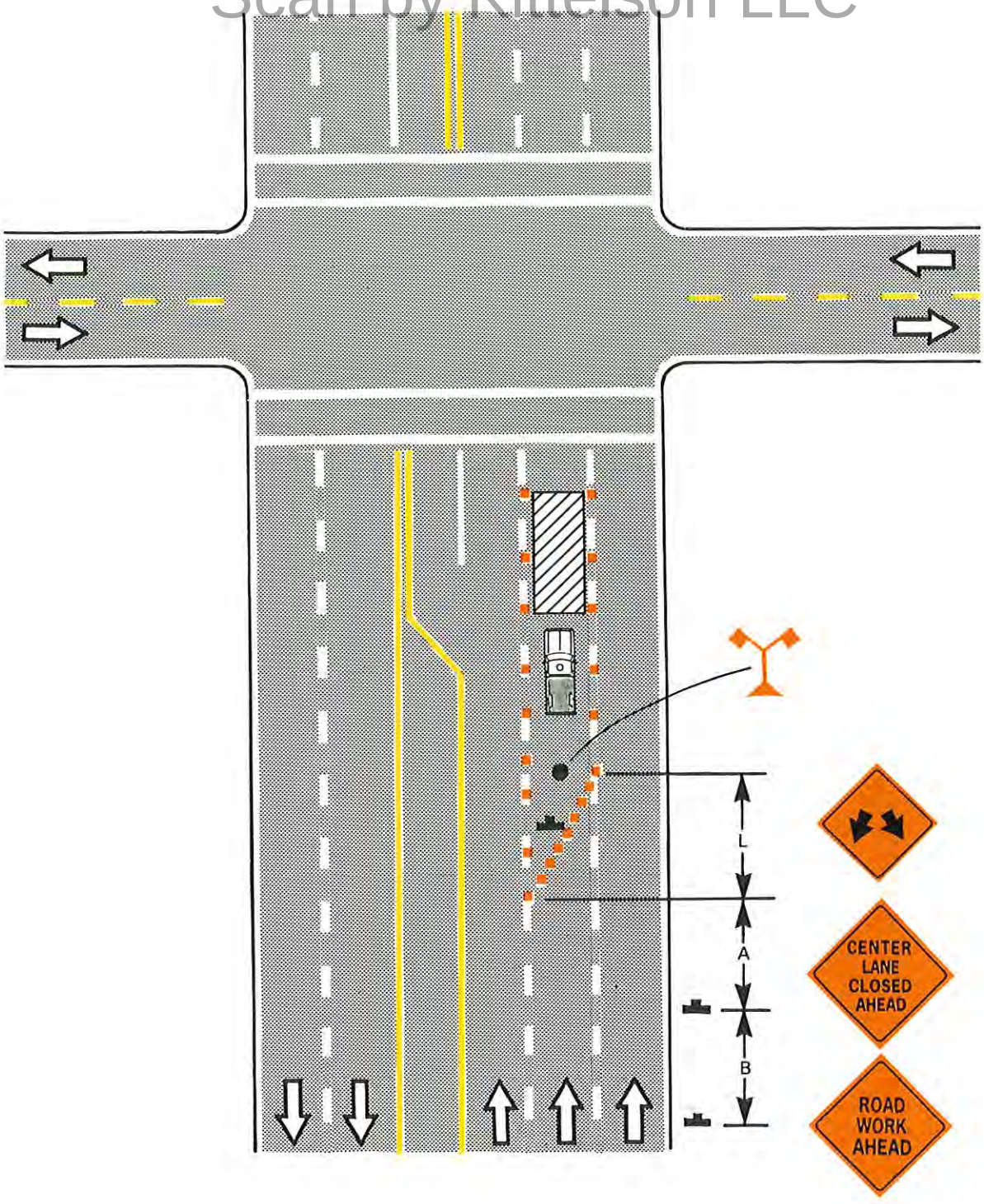

Figure TA-21. Lane closure near side of intersection.

Scan by Kittelson LLC

Right Lane Closure Far Side of Intersection

1. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through traffic.

2. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closing of a right lane having significant right-turning movements, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.

3. Where the turning radius is large, it may be possible to create a right turn island using channelizing devices, as shown. This procedure reinforces the nature of the temporary exclusive right-turn lane and enables a second RIGHT LANE MUST TURN RIGHT sign to be placed in the island.

4. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure TA-29.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

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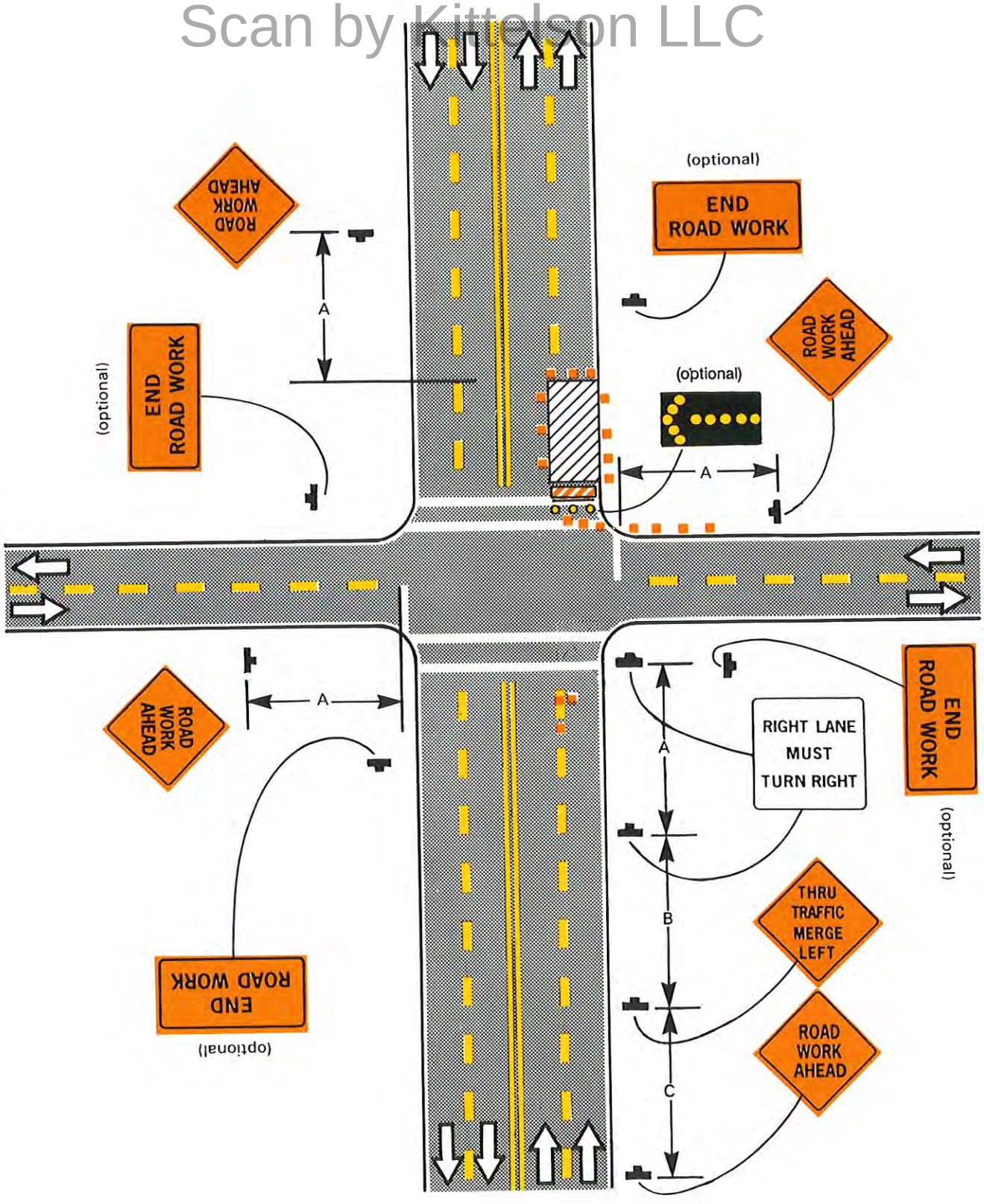

Figure TA-22. Right lane closure far side of intersection.

Scan by Kittelson LLC

Left Lane Closure Far Side of Intersection

1. The standard procedure is to close, on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closure of a left lane having significant left-turning movements, then the left lane may be converted to a turn bay for left turns only, as shown. By first closing off the left lane and then reopening it as a turn bay, an island is created with channelizing devices that allow the LEFT LANE MUST TURN LEFT sign to be repeated on the left, adjacent to the lane that it controls.

2. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure TA-29.

3. Care should be taken to warn drivers of vision obstructions for left-turning vehicles caused by equipment, material, and work operations in the work area.

4. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

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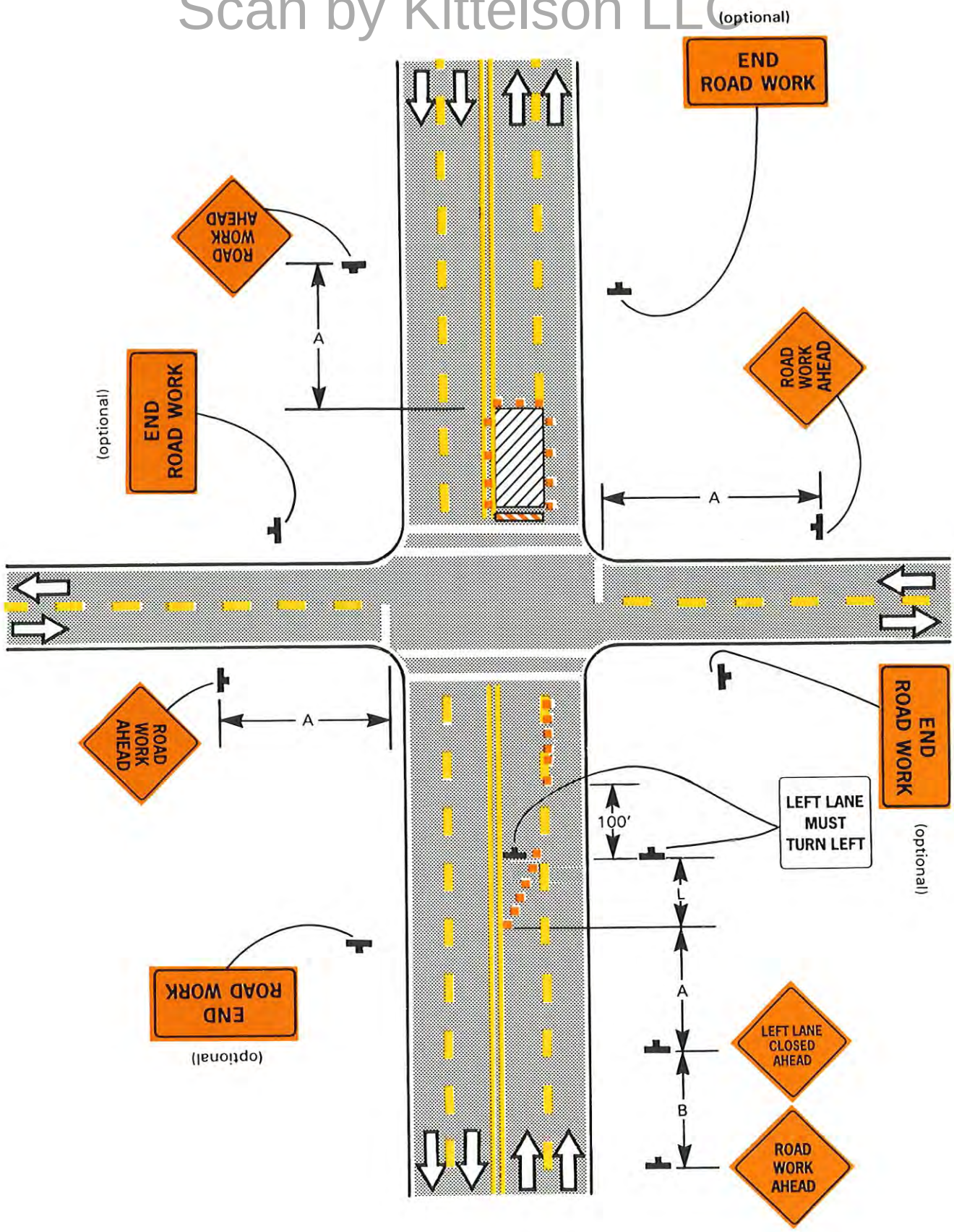

Figure TA-23. Left lane closure far side of intersection.

Scan by Kittelson LLC

Half Road Closure Far Side of Intersection

1. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through traffic.

2. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. Therefore, the right lane should be closed on the near-side approach. However, if there is a significant right-turning movement, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.

3. Where the turning radius is large, it may be possible to create a right-turn island using channelizing devices, as shown. This procedure reinforces the nature of the temporary exclusive right-turn lane and enables a second RIGHT LANE MUST TURN RIGHT sign to be placed in the island.

4. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure TA-29.

5. A buffer space should be used between opposing directions of traffic as shown in this application.

6. There may be insufficient space to place the back-to-back KEEP RIGHT sign and NO LEFT TURN symbol signs at the end of the row of channelizing devices separating opposing traffic flows. In this situation, place the NO LEFT TURN symbol sign on the right and omit the KEEP RIGHT sign.

7. Flashing warning lights and/or flags may be used to call attention to advanced warning signs.

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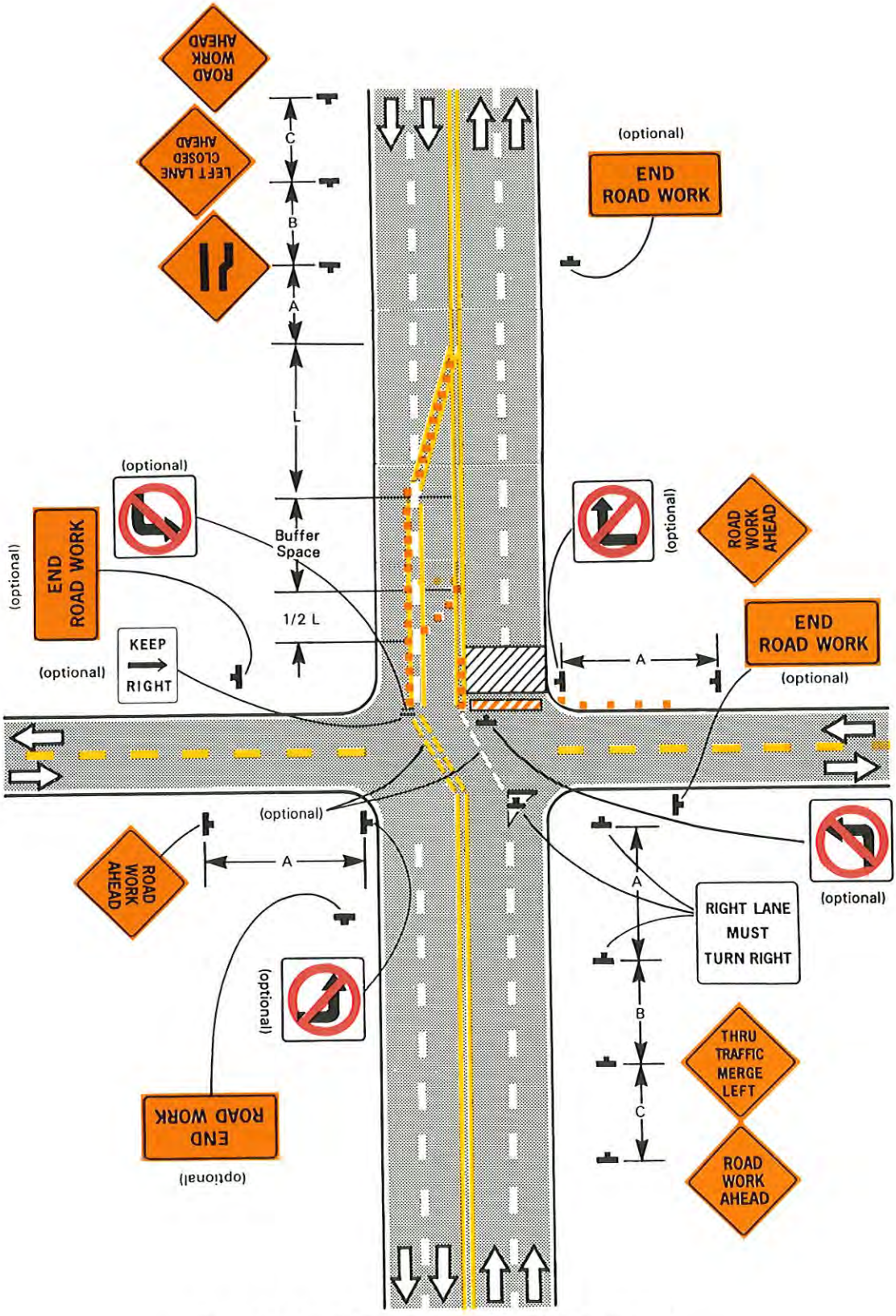

Figure TA-24. Half road closure far side of intersection.

Scan by Kittelson LLC

Multiple Lane Closures at Intersection

1. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. Therefore, the left through lane is closed on the near-side approach. The LEFT LANE MUST TURN LEFT sign is placed in the median to deter through traffic from entering the left turn bay.

2. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure TA-29.

3. If the left-turning movement that normally uses the closed turn bay is small and/or the gaps in opposing traffic are frequent, left turns need not be prohibited on that approach.

4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

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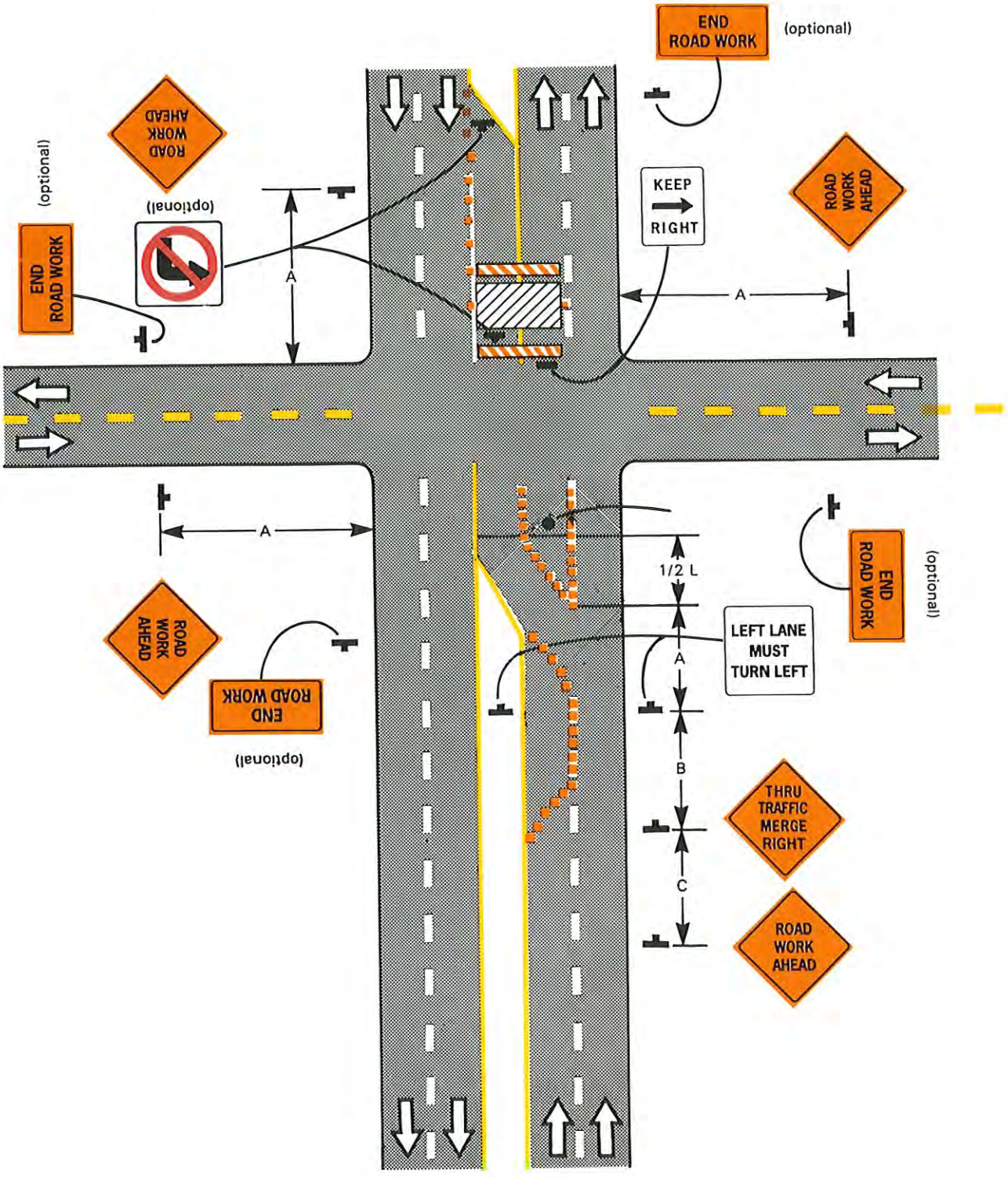

Figure TA-25. Multiple lane closures at intersection.

Scan by Kittelson LLC

Closure in Center of Intersection

1. Prohibit left turns as required by traffic conditions. Unless the streets are wide, it may be physically impossible to turn left, especially for large vehicles.

2. A minimum of six channelizing devices shall be used for each taper.

3. For short-duration work operations, the channelizing devices may be eliminated if a flashing or revolving yellow light is displayed in the work space.

4. A high-level flag tree should be placed in the work space if there is sufficient room.

5. Flashing warning lights and/or flags may be used to call attention to advanced warning signs.

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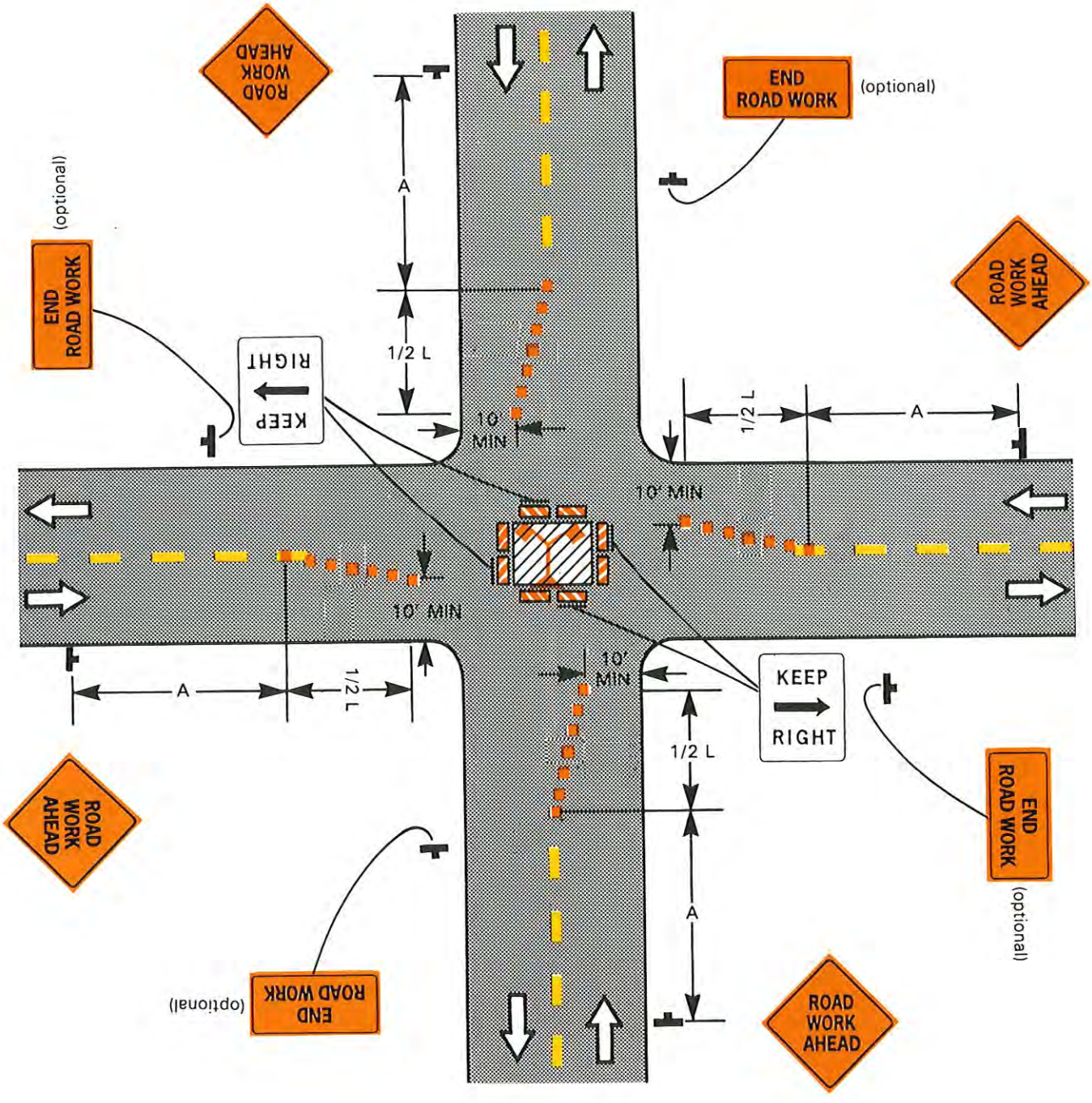

Figure TA-26. Closure in center of intersection.

Scan by Kittelson LLC

Closure at Side of Intersection

1. For low traffic volumes and intersecting two-lane streets, one flagger positioned in the center of the intersection may suffice.

2. For high traffic volumes or when a four-lane street is involved, additional flaggers or law enforcement personnel may be used.

3. A ONE-LANE ROAD AHEAD sign may also be necessary to provide adequate advance warning.

4. The situation depicted can be simplified by closing one or more of the intersection approaches. If this cannot be done, and/or when capacity is a problem, consideration should be given to diverting through traffic to other roads or streets.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

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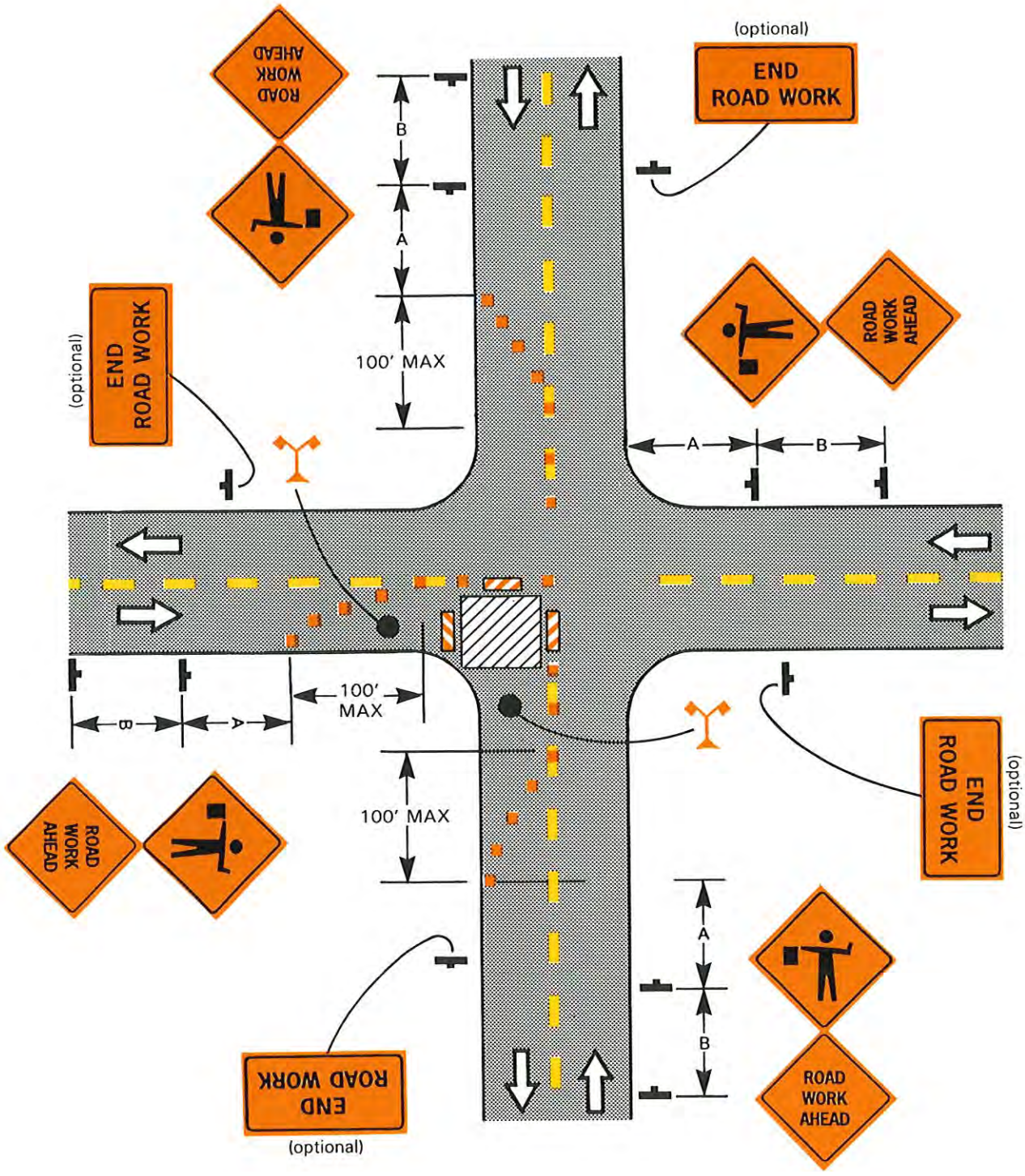

Figure TA-27. Closure at side of intersection.
■ *See note 1 and 2 location of flagger.*

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Sidewalk Closures and Bypass Walkway

1. Additional advance warning may be necessary.

2. Only the traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.

3. Street lighting should be considered.

4. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Type C steady-burn lights may be used on channelizing devices separating the temporary walkway from vehicular traffic.

5. Where high speeds may be anticipated, use a barrier to separate the temporary walkway from vehicular traffic.

6. Signs may be placed along a temporary walkway to guide or direct pedestrians. Examples include KEEP RIGHT and KEEP LEFT signs.

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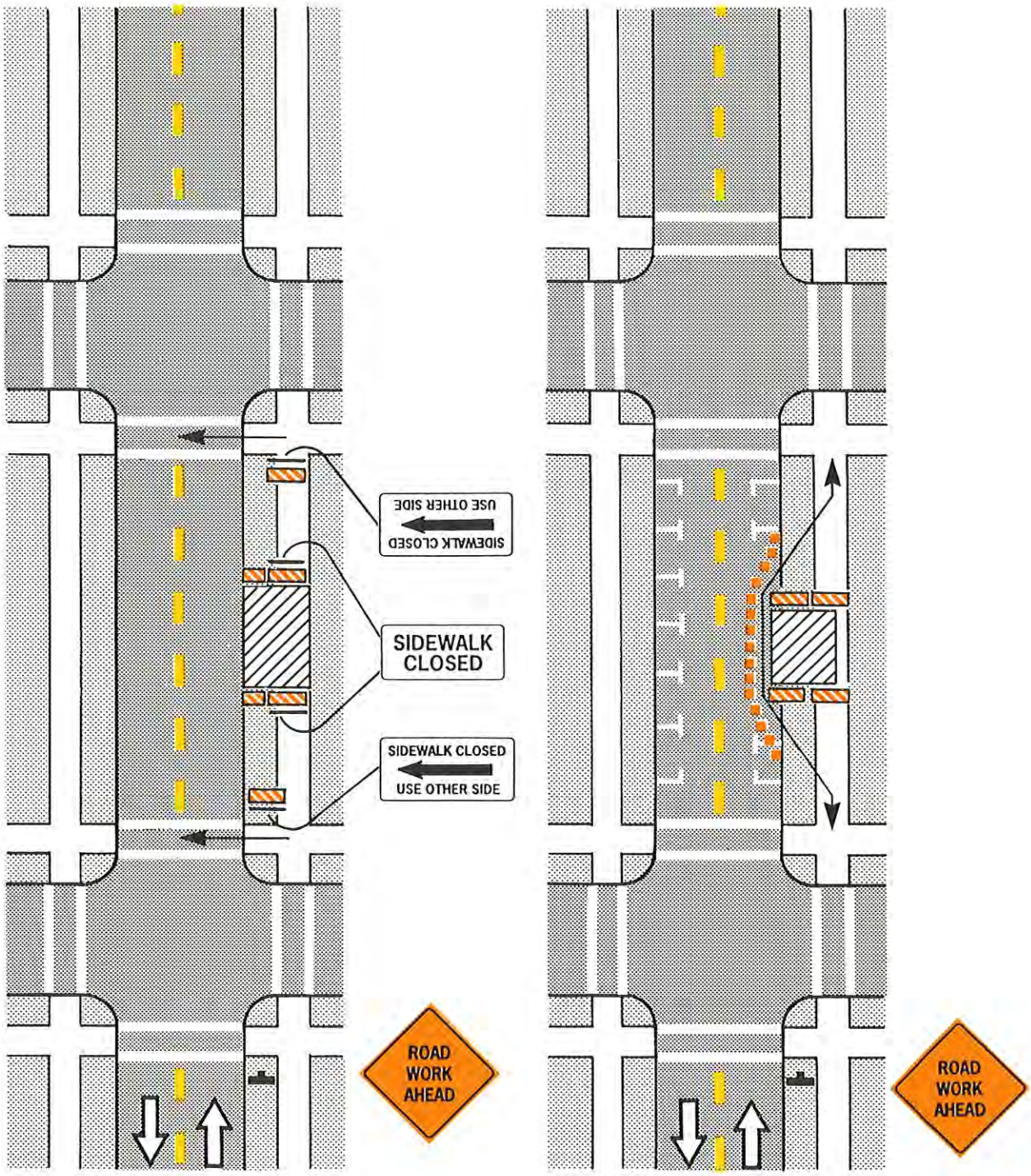

Figure TA-28. Sidewalk closures and bypass walkway.

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Crosswalk Closures and Pedestrian Detours

1. Only the traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.

2. Street lighting should be considered.

3. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Use Type C steady-burn lights on channelizing devices separating the work space from vehicular traffic.

4. Pedestrian traffic signal displays controlling closed crosswalks should be covered or deactivated.

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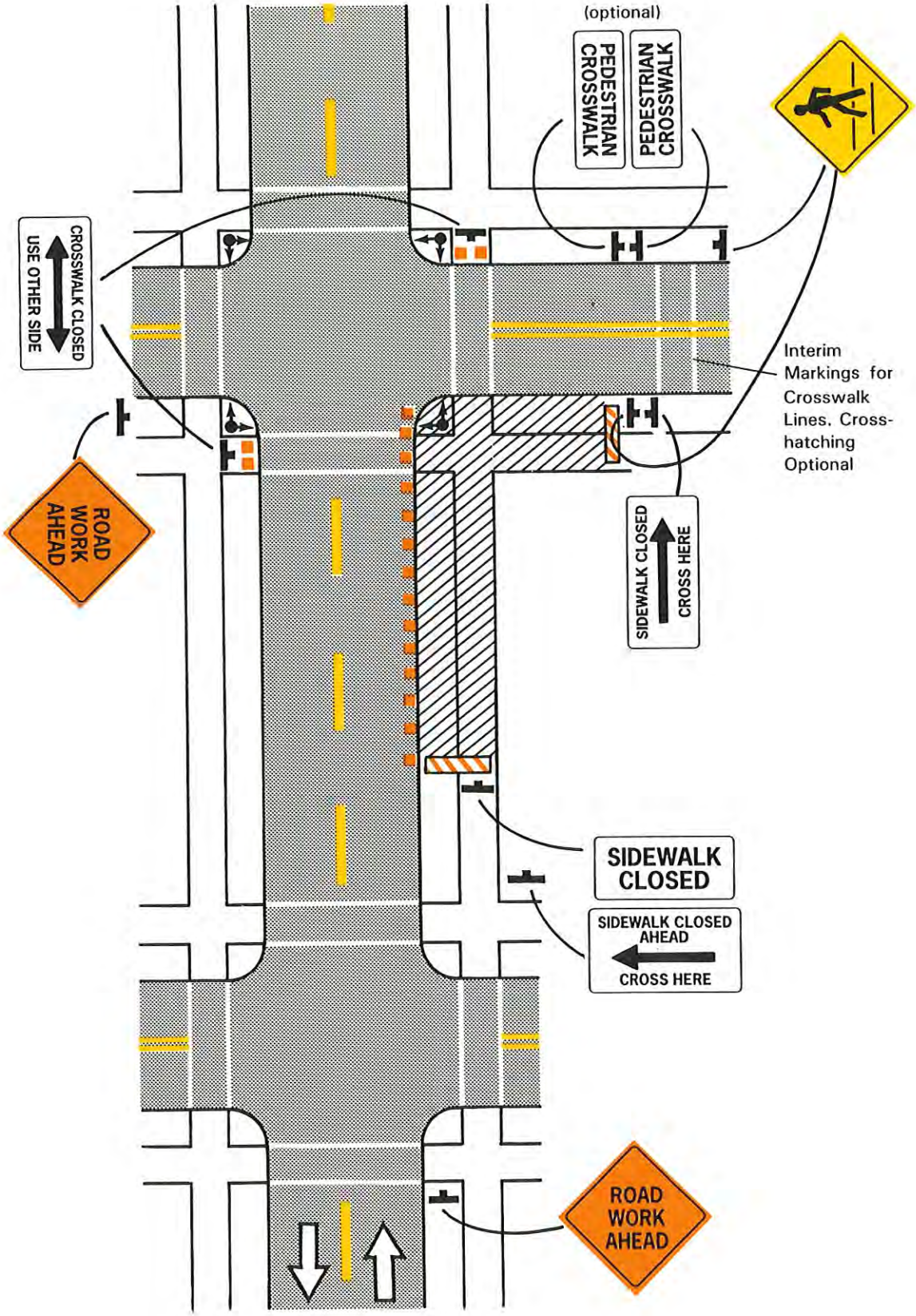

Figure TA-29. Crosswalk closures and pedestrian detours.

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Interior Lane Closure on Multilane Road

1. The closure of the adjacent interior lane in the opposing direction may not be necessary, depending upon the activity being performed and the work space needed for the operation.
2. Additional advance warning may be necessary.
3. This procedure applies to low-speed, low-volume urban streets.

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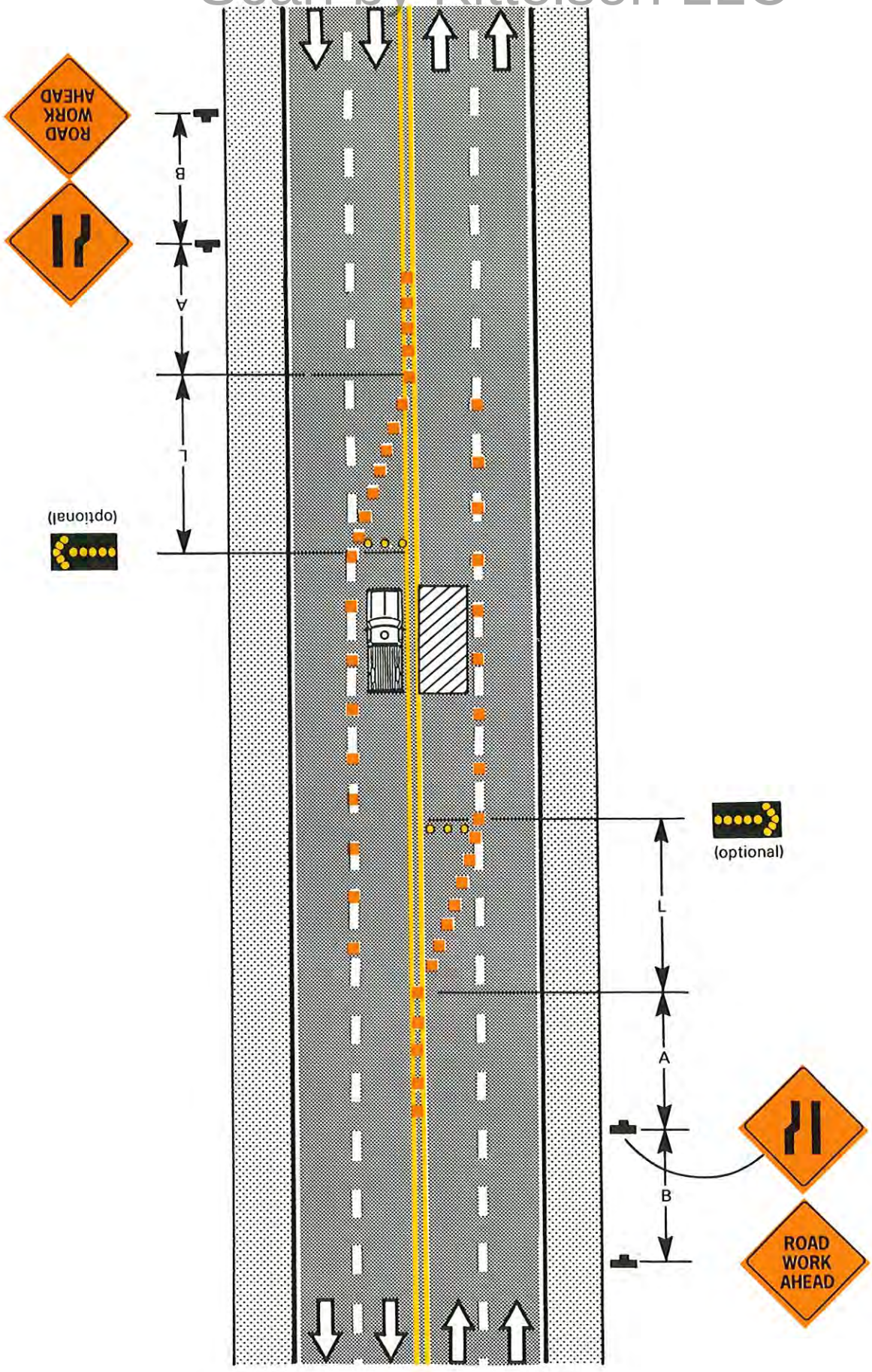

Figure TA-30. Interior lane closure on multilane street.

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Lane Closure on Streets With Uneven Directional Volumes

1. The illustrated procedure would be used only when the traffic volume is such that two lanes of traffic must be maintained in the direction of travel for which one lane is closed. The procedure may be used during a peak period of traffic and then changed to provide two lanes in the other direction for the other peak.

2. The traffic control devices shown are appropriate for an urban street. Additional advance warning may be necessary.

3. A buffer space should be used in the activity area and to separate opposing traffic.

4. Conflicting pavement markings should be removed for long-term projects. (See section 6G-2.) For shorter-term projects when this is not practicable, the channelizing devices in the area of conflict should be placed at a maximum spacing of 10 feet. Interim markings should be installed where needed.

5. For higher speeds, add a W20-5 LEFT LANE CLOSED [distance] sign for traffic approaching the lane closure, as shown in figure TA-32.

6. If the lane shift is short and has sharp curves (30 mph or less), REVERSE TURN signs should be used.

7. Where the shifted section is long, use a REVERSE CURVE sign to show the initial shift and a second one to show the return to the normal alignment. If the shift involves a short runaround, a symbol showing back-to-back reverse curves may be used. As an alternative side-by-side arrows may be used displaying one arrow for each lane. A supplementary plate stating ALL LANES THRU may be used to emphasize the point that no lanes are closed.

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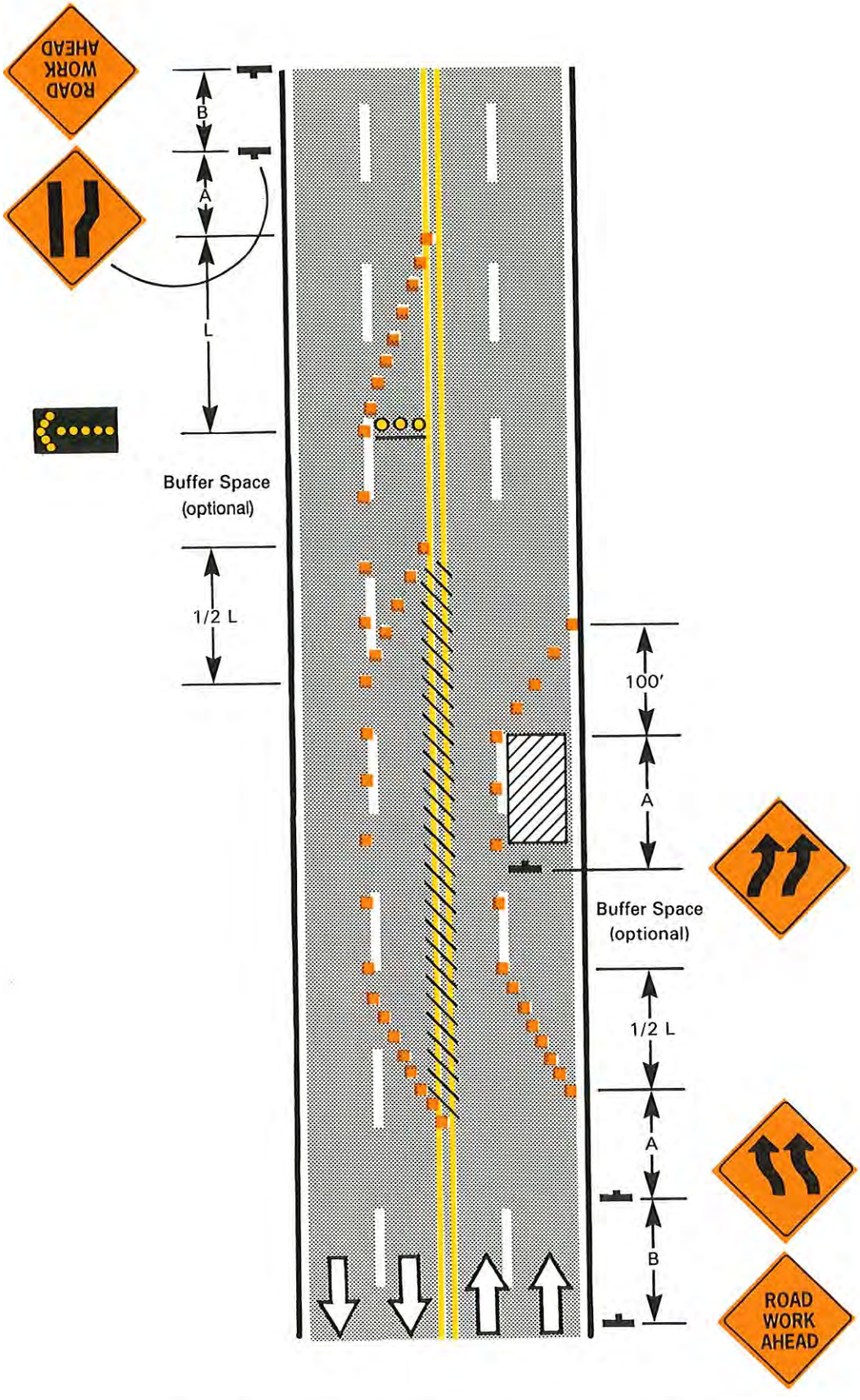

Figure TA-31. Lane closure on streets with uneven directional volumes.

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Half Road Closure on Multilane High-Speed Highways

1. The traffic control devices shown are appropriate for a high-speed highway.

2. Pavement markings no longer applicable shall be removed or obliterated as soon as practicable. Interim markings shall be used as necessary.

3. Warning lights may be used to mark channelizing devices at night as needed.

4. For intermediate-term situations, when it is not feasible to remove and restore pavement markings, the channelization must be made dominant by using a very close device spacing. This is especially important in locations of conflicting information, such as where traffic is directed over a double yellow centerline. In such locations a maximum channelizing device spacing of 10 feet is recommended.

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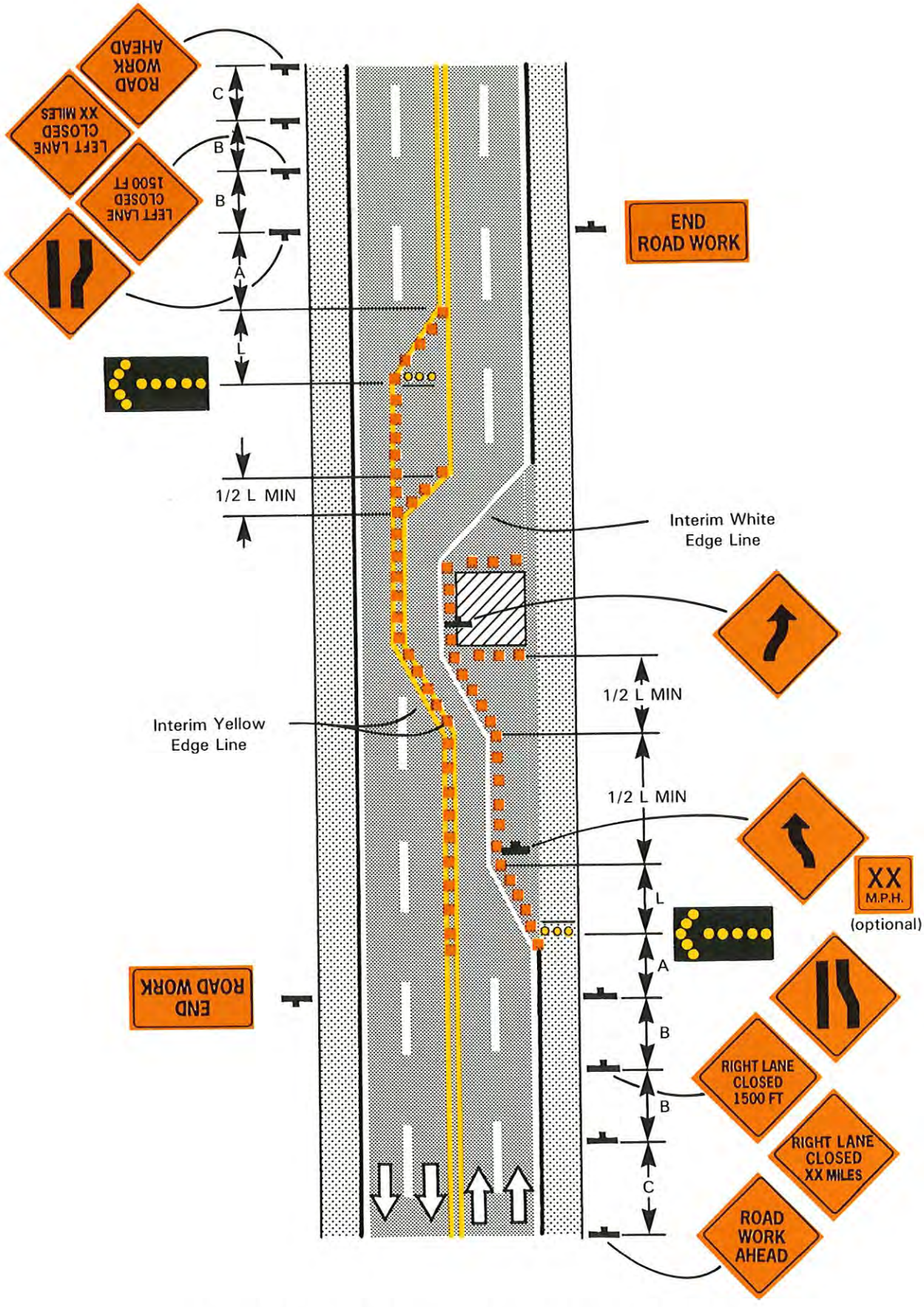

Figure TA-32. Half road closure on multilane high speed highways.

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Lane Closure on Divided Highway

1. This procedure also applies when work is being performed in the lane adjacent to the median on a divided highway. Under these conditions, LEFT LANE CLOSED signs and the corresponding LANE REDUCTION symbol signs shall be used.

2. When a side road intersects the highway within the temporary traffic control zone, additional traffic control devices shall be erected, as needed.

3. Longitudinal dimensions may be adjusted slightly to fit field conditions.

4. All vehicles, equipment, workers, and their activities should be restricted to one side of the pavement.

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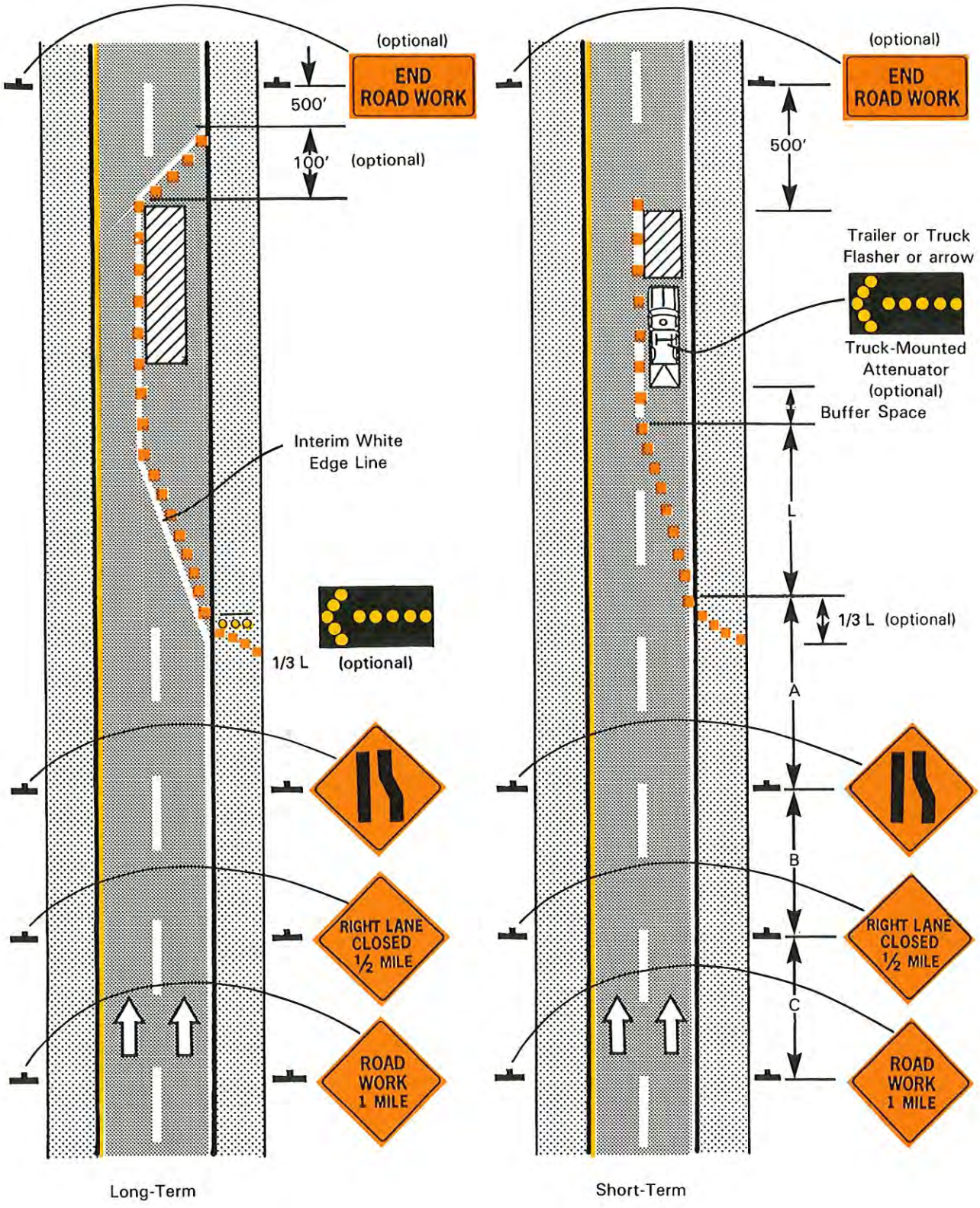

Figure TA-33. Lane closure on divided highway.

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Lane Closure with Barrier

1. Additional advance warning may be necessary.

2. The use of a barrier should be based on the need determined by an engineering analysis.

3. The layout of the barrier should prevent vehicles from impacting the ends of the barrier. To accomplish this, the taper and end should be treated as given in Chapter 9 of the AASHTO Roadside Design Guide (RDG). Example treatments are connecting to an existing barrier, attaching a crashworthy terminal such as a crash cushion or flaring away to the edge of the clear zone.

4. An interim white edge line should be installed from the start of the taper to a point beyond the work area, rejoining the permanent edge line.

5. The barrier shall not be placed along the merging taper. The lane shall first be closed using channelizing devices and pavement markings. The barrier is then placed on a flare beginning beyond the downstream end of the merging taper.

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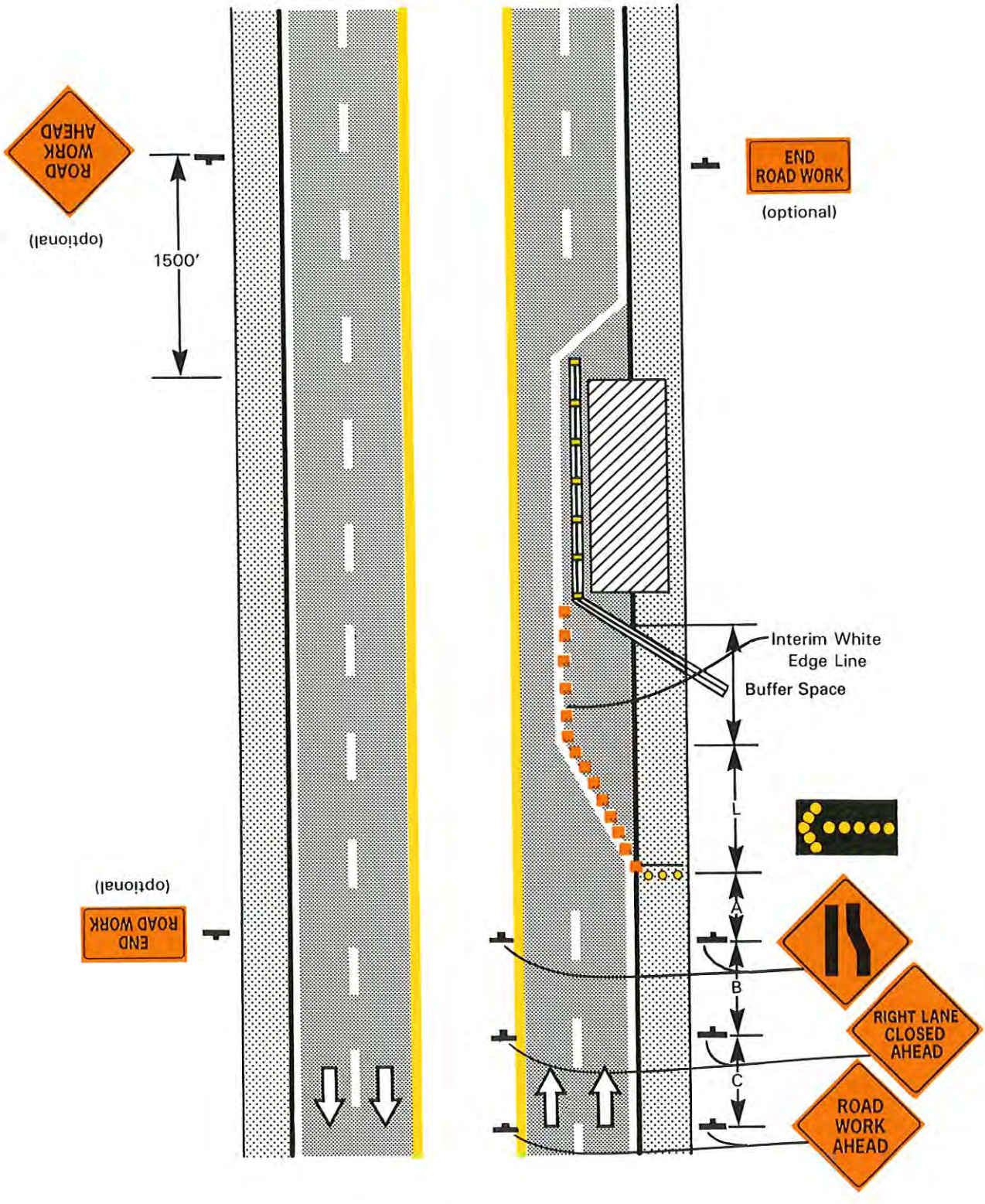

Figure TA-34. Lane closure with barrier.

Scan by Kittelson LLC

Mobile Operation on Multilane Road

1. Vehicles used for these operations should be made highly visible with appropriate equipment, such as flashing lights, rotating beacons, flags, signs, or arrow displays.

2. Protection vehicle #1 should be equipped with an arrow display. An appropriate lane closure sign should be placed on protection vehicle #1 so as not to obscure the arrow display.

3. Protection vehicle #2 should be equipped with an arrow display and truck-mounted attenuator.

4. Protection vehicle #1 should travel at a varying distance from the work operation so as to provide adequate sight distance for traffic approaching from the rear.

5. When adequate shoulder width is not available, protection vehicle #1 should be eliminated.

6. On high-speed roadways, a third protection vehicle should be used-vehicle #1 on the shoulder (if possible), vehicle #2 in the closed lane, and vehicle #3 in the closed lane.

7. Arrow displays shall be as a minimum Type B, 60 inches by 30 inches (figure VI-9, section 6F-3).

8. Work should normally be done during off-peak hours.

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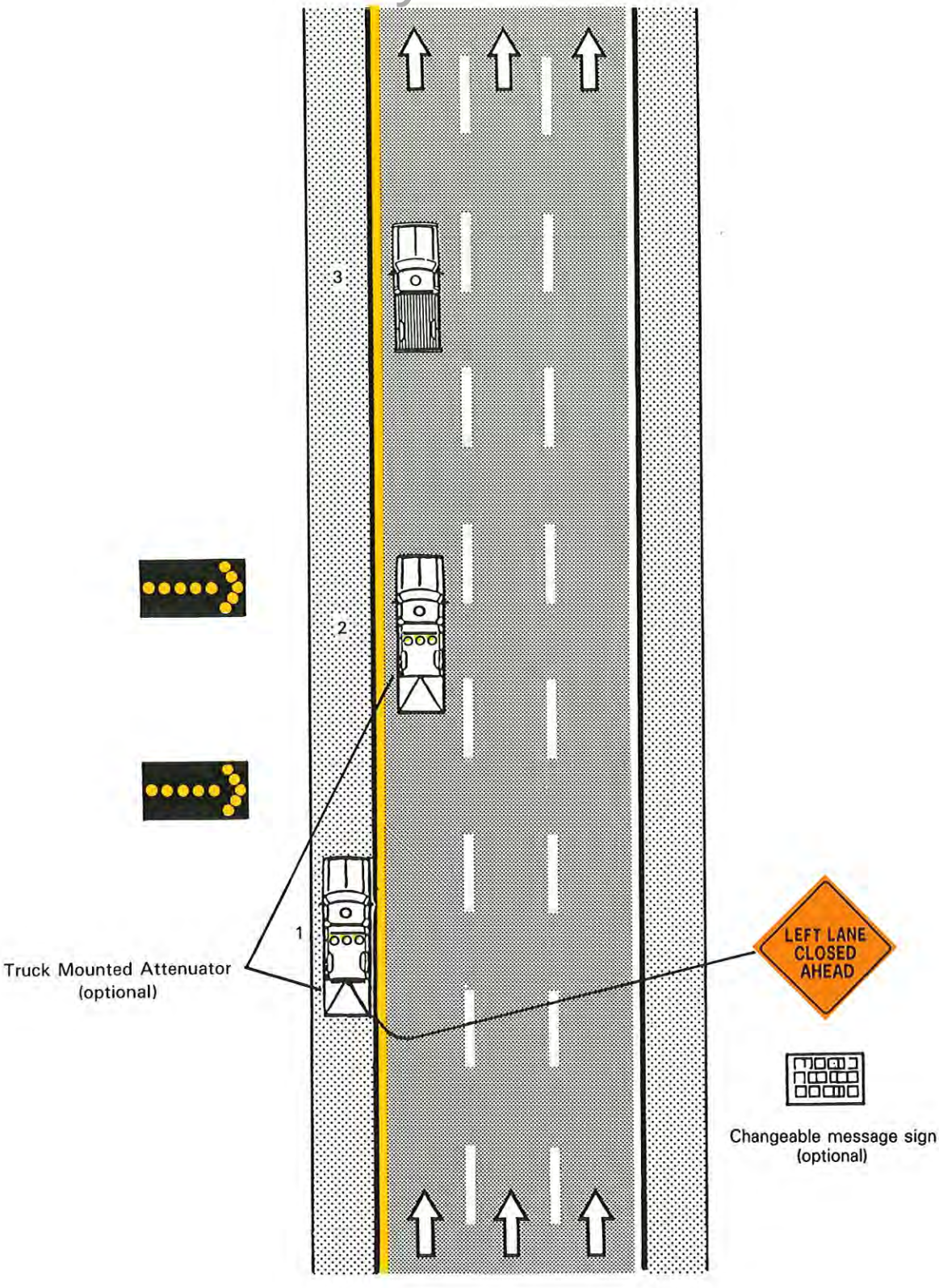

Figure TA-35. Mobile operation on multilane road.

Scan by Kittelson LLC

Lane Shift on Freeway

1. The lane shift should be used when the work space extends into either the right or left lane of a divided highway and it is not practicable, for capacity reasons, to reduce the number of available lanes. The minimum width of the shoulder lane is 10 feet.

2. The best way to handle lane shifting is to use: (1) a geometry which meets that design speed at which the permanent highway was designed, (2) full normal cross-section (full lane width and full shoulders), and (3) complete pavement markings. If this can be done, then no temporary traffic control devices may be needed other than the initial general work-zone warning sign. If a lesser alignment is used, then for long-term use the lane lines should be changed to solid white, and a warning sign that shows the changed alignment is needed.

3. Where the shifted section is long, one set of REVERSE CURVE signs shows the initial shift and a second set show the return to the normal alignment. If the shift involves a short runaround, a symbol showing back-to-back reverse curves may be used. As an alternative side-by-side arrows may be used displaying one arrow for each lane. A supplementary plate stating ALL LANES THRU may be used to emphasize the point that no lanes are closed.

4. If the STAY IN LANE sign is used, then solid, white lane lines should be used.

5. The barrier shown in this diagram is one method that may be used to close a lane for a long-term project. Use of a barrier should be based on the need determined by an engineering analysis. The layout of the barrier should prevent vehicles from impacting the ends of the barrier. According to the Roadside Design Guide (RDS), the barrier should be flared beyond the clear zone. An alternative procedure is to place an impact attenuator to protect traffic from the end of the barrier.

6. Type C steady-burning warning lights may be placed on channelizing devices and the barrier parallel to the edge of pavement for nighttime lane closures. The maximum spacing should be identical to the channelizing device spacing.

7. Existing conflicting pavement markings shall be removed and temporary markings shall be installed before traffic patterns are changed. Removable pavement markings may be used. After completion of the work temporary markings shall be removed. When a lane closure is limited to daylight hours, lanes may be delineated by channelizing devices in lieu of temporary markings.

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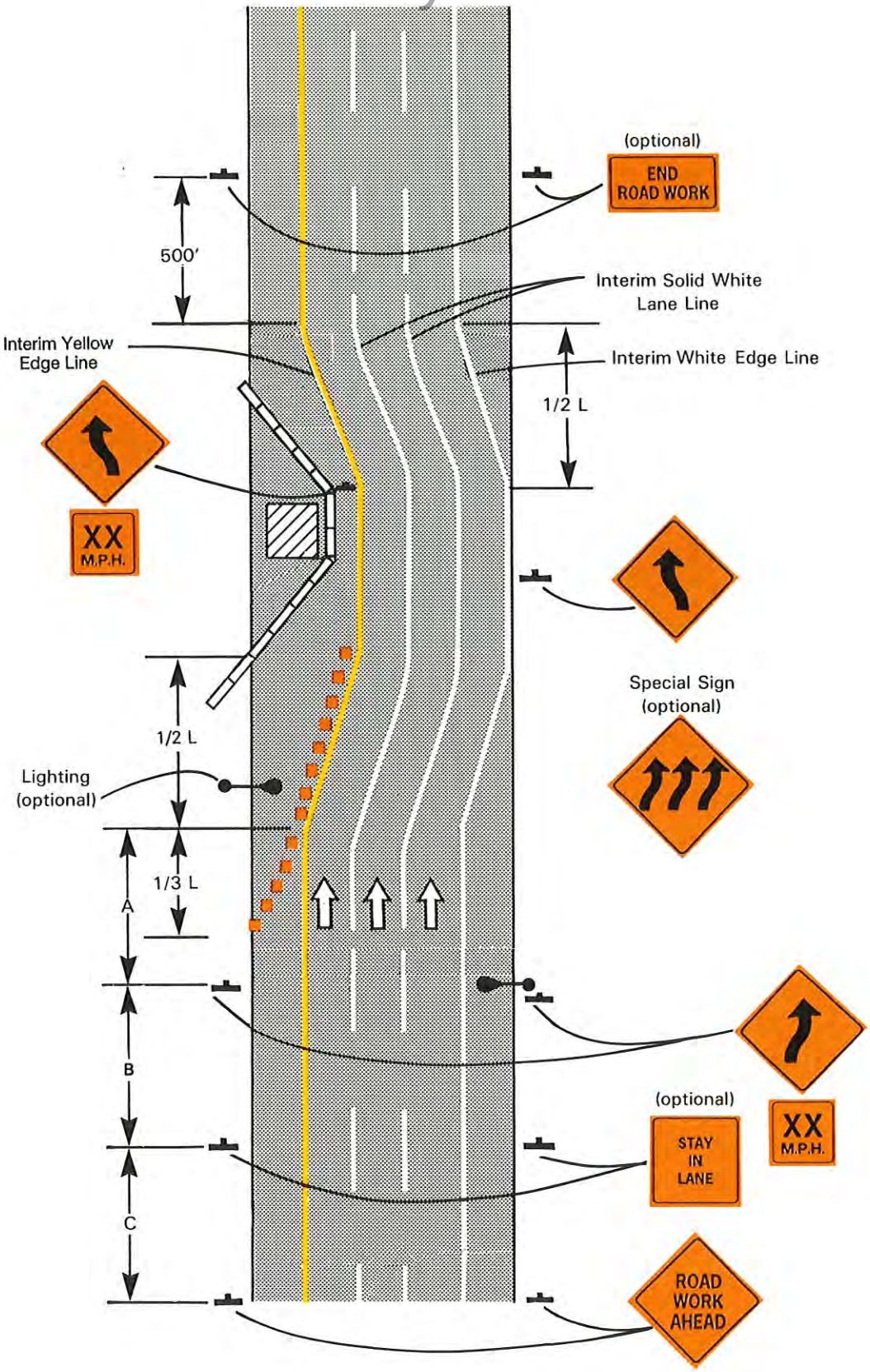

Figure TA-36. Lane shift on freeway.

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Double Lane Closure on Freeway

1. Flashing warning lights and/or flags may be used to call attention to the initial warning signs.

2. Ordinarily, the preferred position for the second arrow display is in the closed interior lane at the beginning of the second merging taper. In the following situations, however, the second arrow display should be placed in the closed exterior lane at the end of the second merging taper.

    (a) When a protection vehicle is used in the interior closed lane, and the second arrow display is mounted on the protection vehicle.
    (b) If alignment or other conditions create any confusion as to which lane is closed by the second arrow display.
    (c) When the first arrow display is placed in the closed exterior lane at the end of the first merging taper (the alternative position when the shoulder is narrow).

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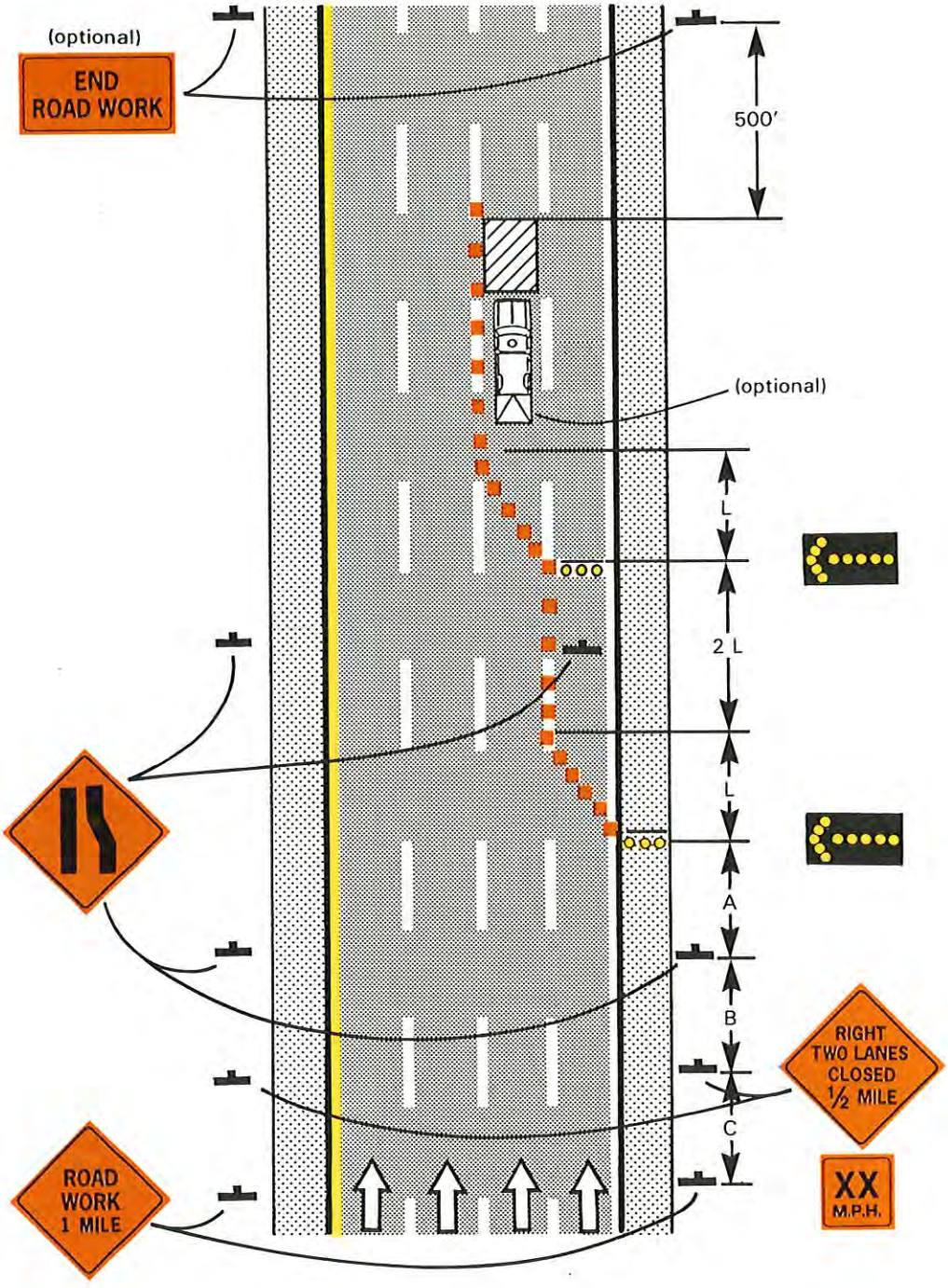

Figure TA-37. Double lane closure on freeway.

Scan by Kittelson LLC

Interior Lane Closure on Freeway

1. Additional advance warning may be necessary.

2. A buffer space should be used at the upstream end of the closed interior lane. For long-term operation a barrier should be used to protect the operation in the closed interior lane.

3. Traffic operations may be improved by adding a short, single row of channelizing devices in advance of the traffic split to restrict traffic to their respective lanes.

4. This operation involves an initial exterior lane closure followed by a lane shift. The right lane should continue, and the center lane must shift to the left. This is best handled with a special sign showing the situation symbolically.

5. For long-term use, the dashed lane lines should be made solid white in the two-lane section. DO NOT PASS signs may be used.

6. The first arrow display with a right arrow should be on the left shoulder at the beginning of the taper. This arrow display may be omitted if the alignment is such that the two panels create confusion. The arrow display with a double-headed arrow is the key one. It should be fully centered in the closed interior lane and placed at the downstream end of the shifting taper.

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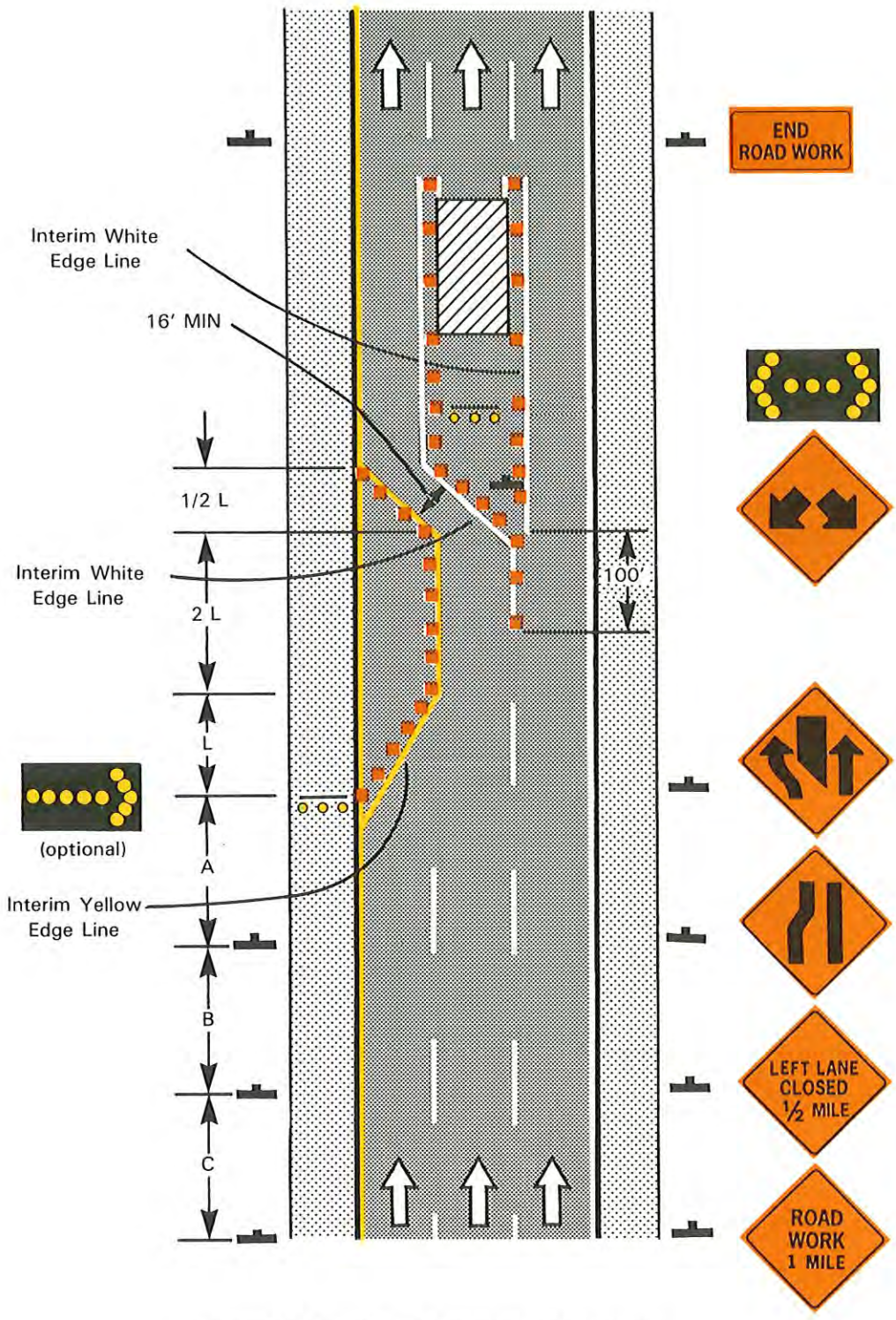

Figure TA-38. Interior lane closure on freeway.

Scan by Kittelson LLC

Median Crossover on Freeway

1. The sign legends for the four pairs of signs approaching the lane closure for the non-crossover direction of travel are not shown. They are similar to the series shown for the crossover direction, except that the left lane is closed.

2. The alignment of the crossover may be designed as a reverse curve using design criteria contained in the AASHTO *Policy on the Geometric Design of Highways and Streets*.

3. Channelizing devices should be used to separate opposing traffic between the two median crossovers. When the distance is sufficiently short that motorists entering the section can see the far end of the section, they are less likely to forget that there is opposing traffic. On long-term projects on high-speed highways, consideration should be given to the use of barriers for this function.

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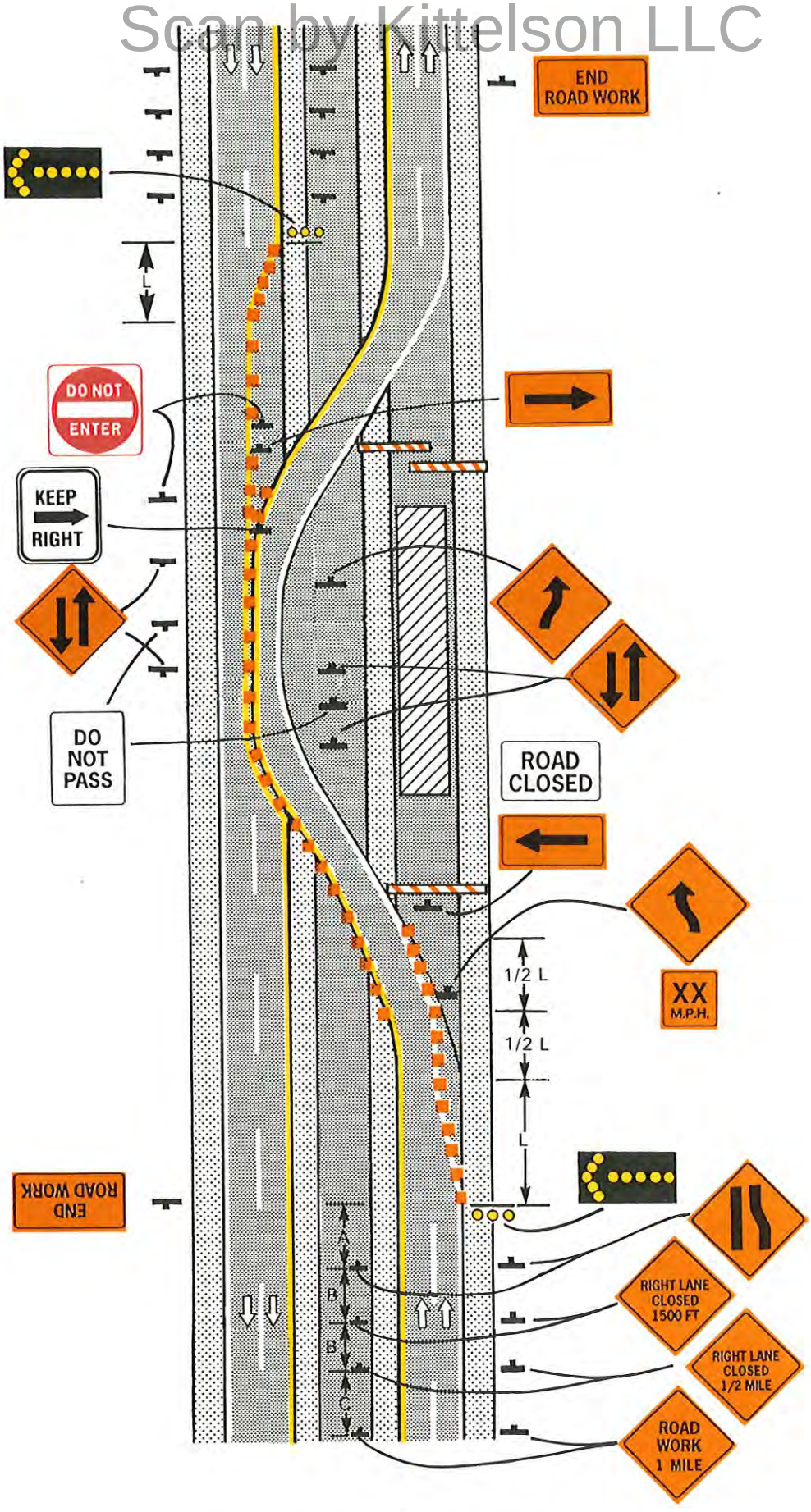

Figure TA-39. Median crossover on freeway.

Scan by Kittelson LLC

Median Crossover for Entrance Ramp

1. This diagram illustrates the procedure for carrying an entrance ramp across a closed directional roadway of a divided highway. If insufficient gaps are available, consideration should be given to closing the ramp. In some instances, a temporary acceleration lane may be useful in facilitating the merging maneuver.

2. The STOP sign should be located sufficiently far forward to provide adequate sight distance of oncoming mainline traffic to select a safe gap. Also, where feasible, acceleration distance should be provided beyond the stop location to reduce the gap size needed.

3. The temporary STOP sign should be turned to face ramp traffic and diminish its visibility to mainline traffic. Where view of the temporary STOP sign may be confusing to mainline traffic, a white-on-red supplementary plate may be added below, reading ON RAMP.

4. A temporary stop line should be placed across the ramp at the desired stop location. Consideration should be given to placing a Type B high-intensity flasher with a red lens above the stop sign.

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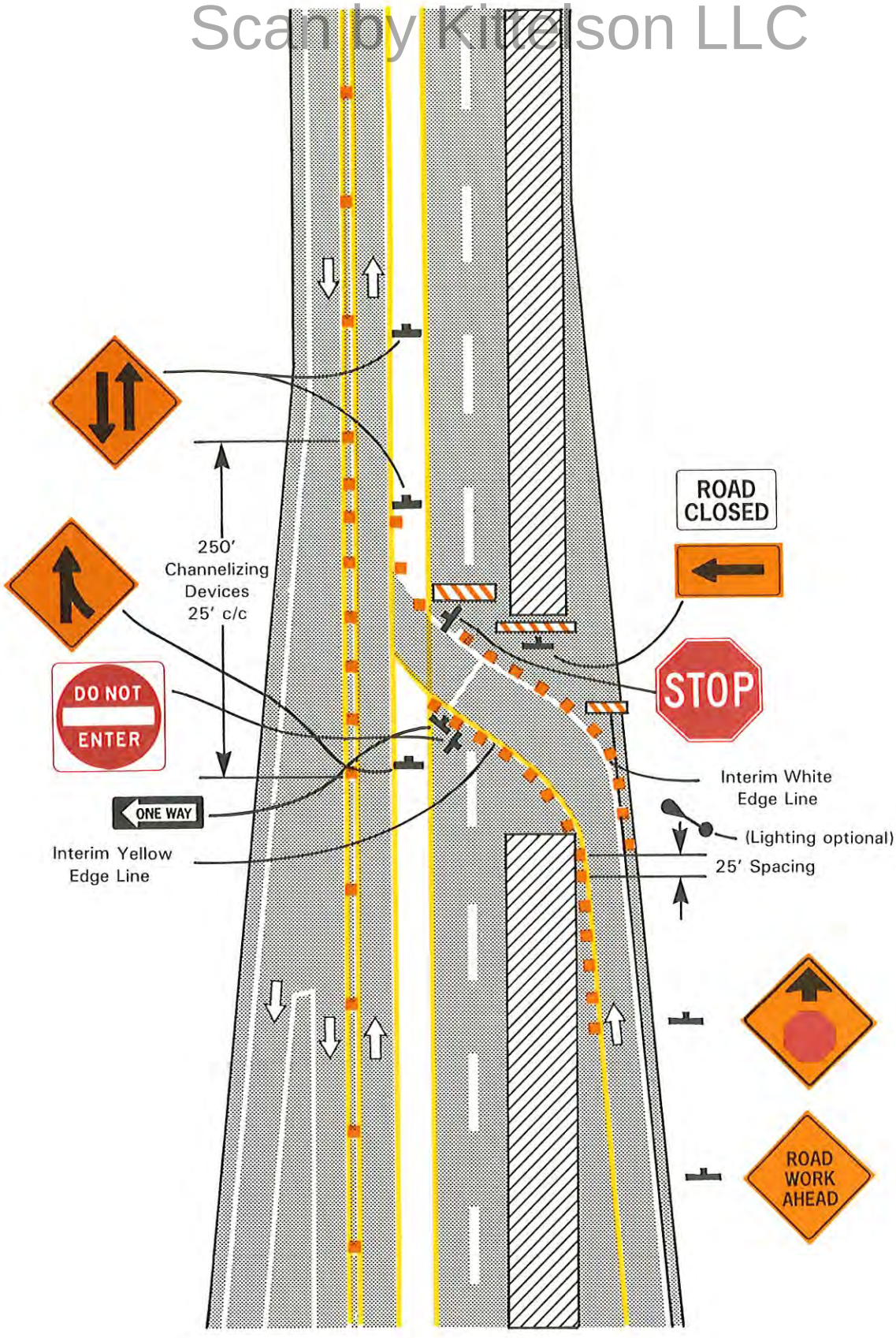

Figure TA-40. Median crossover for entrance ramp.

Scan by Kittelson LLC

Median Crossover for Exit Ramp

1. This diagram illustrates the procedure for carrying an exit ramp across a closed directional roadway of a divided highway. Guide signs referring to the exit may need to be relocated to the median. The guide signing should indicate that the ramp is open, and where the temporary ramp is located. Conversely, if the ramp is closed, the guide signing should also provide this information.

2. A temporary EXIT sign with a diagonal arrow to the right shall be located in the temporary gore adjacent to the mainline roadway. Typically, a black-on-orange sign is used, but the standard white-on-green sign may be used. The mounting height for this sign shall be a minimum of 3 feet from the pavement surface to the bottom of the sign.

3. In the situation (not shown) where channelizing devices are placed along the mainline roadway, the devices' spacing should be reduced in the vicinity of the off ramp to emphasize the opening at the ramp itself. Channelizing devices and/or temporary pavement markings should be placed on both sides of the temporary ramp where it crosses the median and the closed roadway.

4. Where possible, a temporary deceleration lane may be useful in facilitating the exiting maneuver.

5. Advance guide signs providing information related to the temporary exit should be relocated or duplicated adjacent to the temporary roadway.

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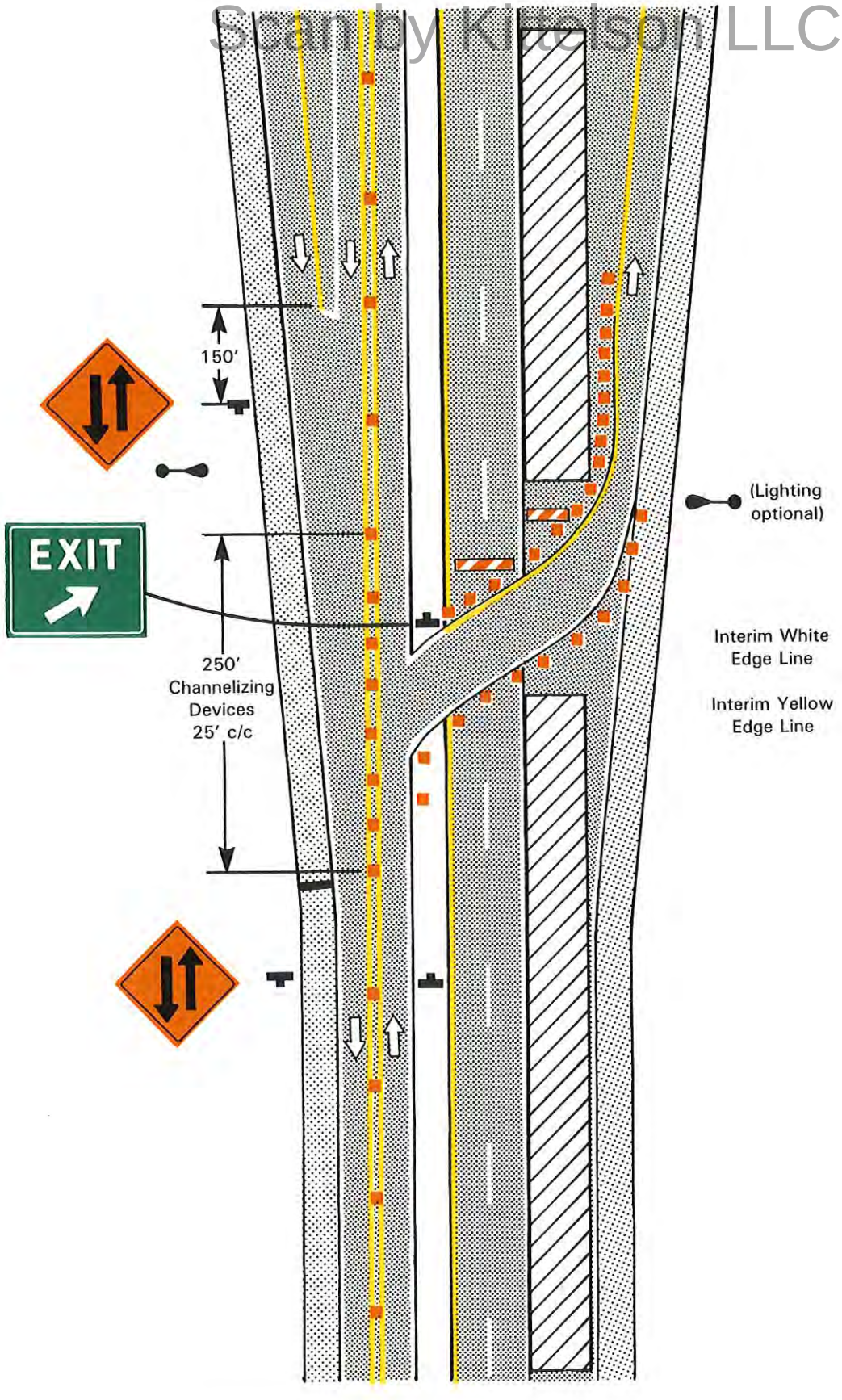

Figure TA-41. Median crossover for exit ramp.

Scan by Kittelson LLC

Work in Vicinity of Exit Ramp

1. Additional advance warning may be necessary. The guide signing should indicate that the ramp is open, and where the temporary exit terminal is located. Conversely, if the ramp is closed the guide signing should also provide this information.

2. A buffer may be used.

3. An alternative is to channelize exiting traffic onto the right shoulder, and close the lane as necessary. The shoulder should be used only if it has sufficient width and structural capacity.

4. The temporary EXIT sign mounted in the temporary gore shall be clearly visible. It must be mounted high enough so that it can be seen over the channelizing devices. The mounting height for this sign shall be a minimum of 3 feet from the pavement surface to the bottom of the sign.

5. If the exit is closed, this information should be clearly provided. An effective method is to place a black-on-orange plate reading EXIT CLOSED diagonally across the interchange/intersection guide signs.

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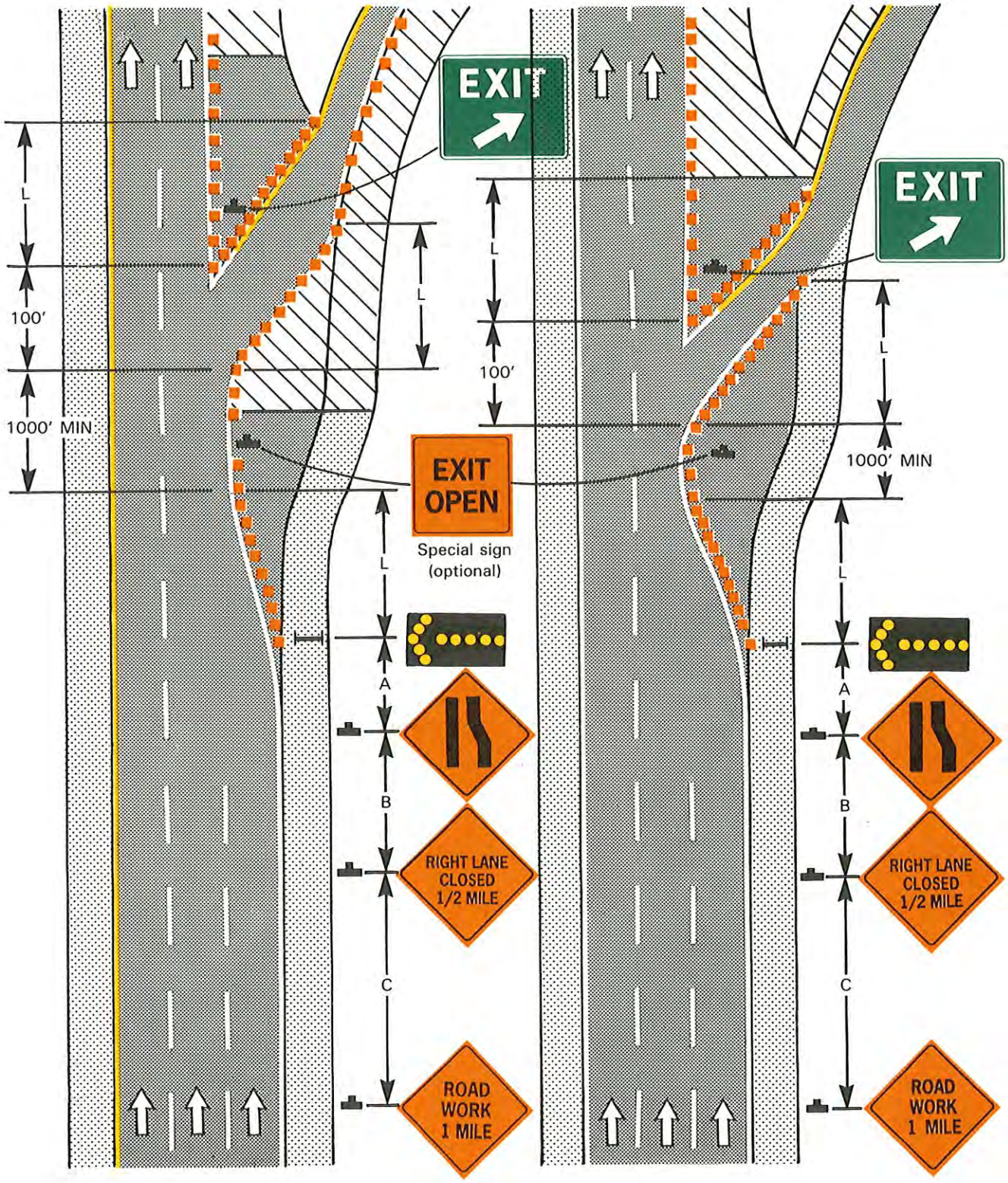

Figure TA-42. Work in vicinity of exit ramp.

Scan by Kittelson LLC

Partial Exit Ramp Closure

1. As an alternative to the supplementary plate reading ON RAMP, a RAMP WORK [XXX] FT sign may be used.

2. Truck off-tracking should be considered when determining whether the 10-foot minimum lane width is adequate.

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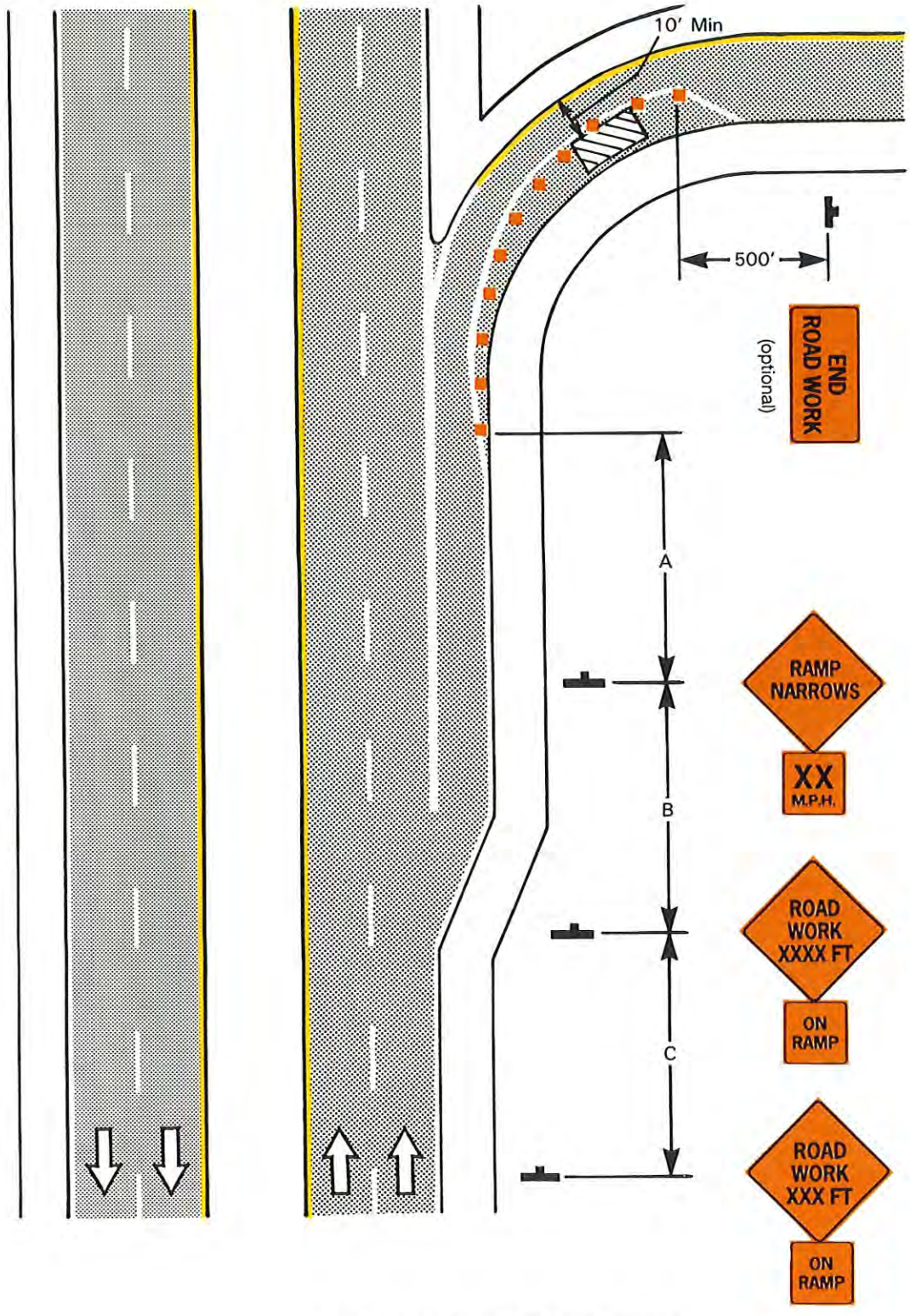

Figure TA-43. Partial exit ramp closure.

Scan by Kittelson LLC

Work in Vicinity of Entrance Ramp

1. The right lane needs to be closed sufficiently far in advance to stabilize traffic flow before encountering the merge.

2. For the procedure shown on the right side of the diagram, the YIELD sign shall be replaced with STOP signs (one on each side of the approach), if no adequate acceleration lane exists for the temporary entrance. The STOP or YIELD sign should be located sufficiently far forward to provide adequate sight distance of oncoming mainline traffic in order to select a safe gap. Also, acceleration distance should be provided beyond the sign to reduce the gap size needed. If insufficient gaps are available, consideration should be given to closing the ramp.

3. Where STOP signs are used, a temporary stop line should be placed across the ramp at the desired stop location. Consideration should be given to placing a Type B high-intensity flasher with a red lens above the stop sign.

4. The mainline merging taper with the arrow display at its starting point should be located sufficiently far upstream so that the arrow display is not confusing to motorists on the entrance ramp.

5. If the ramp curves sharply to the right, place pairs of signs (one on each side of the ramp) for warning signs located before the entrance terminal.

6. Where the acceleration distance is significantly reduced, a supplemental plate may be placed below the YIELD AHEAD sign, reading NO MERGE AREA.

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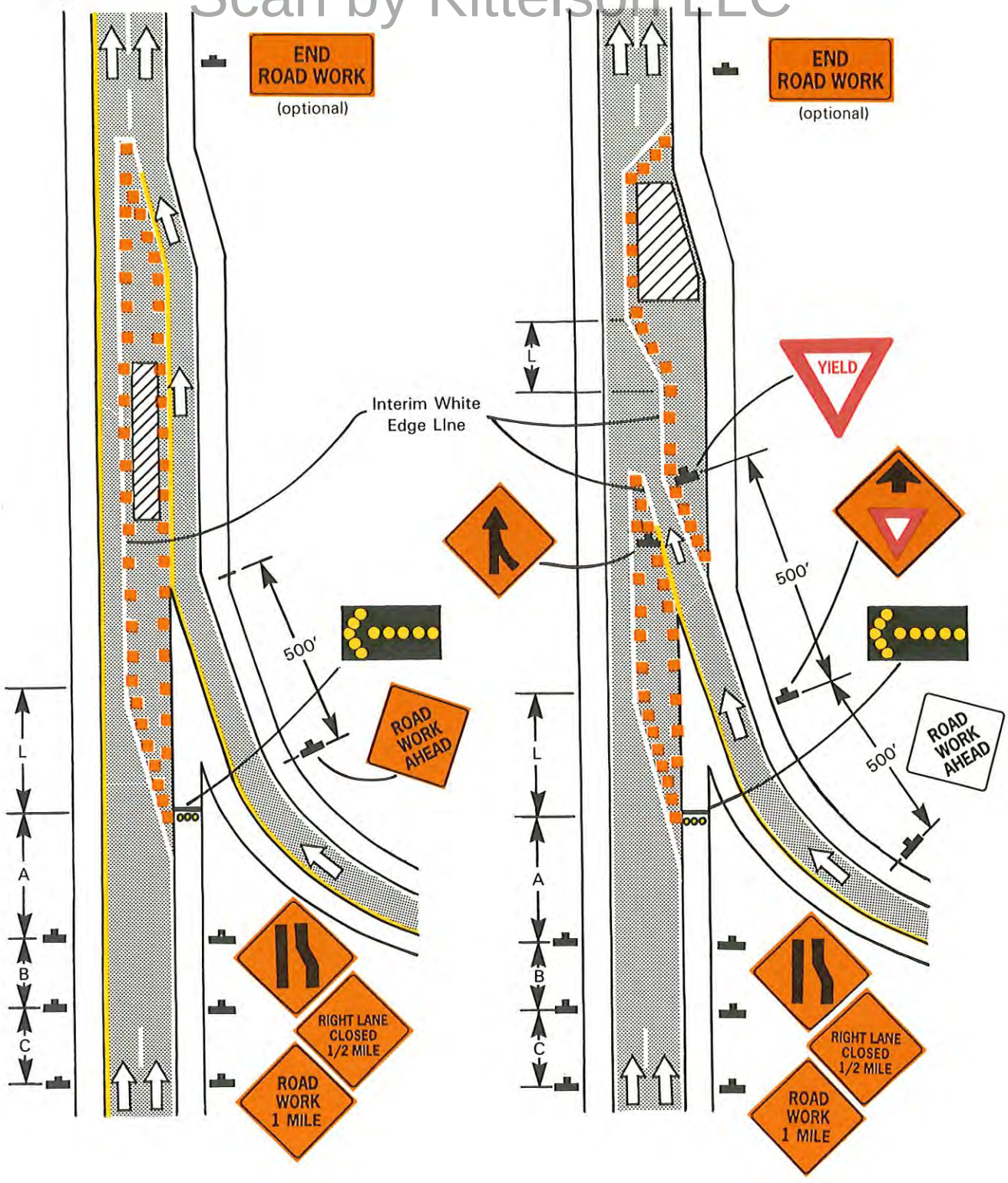

Figure TA-44. Work in vicinity of entrance ramp.

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